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Report developed under SBIR contract. This effort resulted in a "Human Response to Stimuli" Federation Object Model. During this effort, an investigation into the representation of stimuli vis-a-vis the human recipient was performed. A Stimuli simulation object model and a Physiological simulation object model were developed prior to the construction of the FOM.

As the present effort did not originate with legacy simulations, the first issue was to address the conceptual model of the mission space. In the development of the Stimuli SOM, the questions of scalability, relevance of stimuli, and characterization of stimuli were addressed. The effort resulted in the creation of a set of informational attributes and the concept of simple versus complex stimuli. Both "local" and "global" stimuli are considered. In the representation of the human body, physiological functioning guided the development of the Physiological SOM. Object oriented techniques were heavily utilized in populating this SOM. The question of extensibility, which has ramifications for distance education, is discussed. Different emphasis on intended utilization of the Federation resulted in two divergent FOM structures. Scenarios relevant to this Federation are presented in detail.

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Chapter 1—Introduction and Executive Overview

1.1 Introduction

The overarching focus of this project was on the "Representation of Non-visual Stimuli as a Precursor to Mannequin Stimulation over the Internet". As is evident from the title, the work of this project involved the preliminary background effort that is necessary in order to prototype the stimulation of a mannequin in a distributed setting. (Prototyping was planned for the Phase II stage.) What is not clearly communicated by the title, but what is no less an important component of the intended effort, is the machinery of the HLA is to be utilized in reaching the prototyping stage.

The mannequin in question is a medical mannequin that has the fidelity to be used as an instructional tool in medical schools throughout the United States. Of course, development must be done in order for the mannequin to recognize any communications that are through the HLA conduits.

This preliminary Phase I effort has been theoretical. The nature of stimuli and the question of how to characterize stimuli in terms of their respective effects on human physiology have been investigated. Even the question of the choice of which stimuli to include is predicated upon their ability to evoke a reaction from the human physiological system. Ramifications of decisions as to the boundaries between the modeling of a stimulus and the modeling of its effect in the human physiological system have been investigated. The separation of stimuli into the simple and complex categories was the result of certain of these investigations.

Constraints on the modeling of human physiological systems arise from the requirement that the functionality should be reproduced. Moreover, the features of the physiological systems modeling should include clinical quantities which are so important to the functioning of the mannequin. In this Phase I effort, the focus of the modeling effort has been to capture the behavior and the functionality of the respiratory system and the cardiovascular system.

The Object Model Template component of the High Level Architecture serves to organize the modeling of both the stimuli and the human physiological systems, as well as their methods of interacting. It does this through the structure of the Simulation Object Models; with separate SOM' s constructed for the stimuli modeling and for the physiological systems modeling. The structure of the ultimate interoperation of different simulations is given in a Federation Object Model, or

FOM. In the context of two simulations, the stimuli simulation and the physiological simulation, their interoperating could be expressed in a "human response to stimuli" federation.

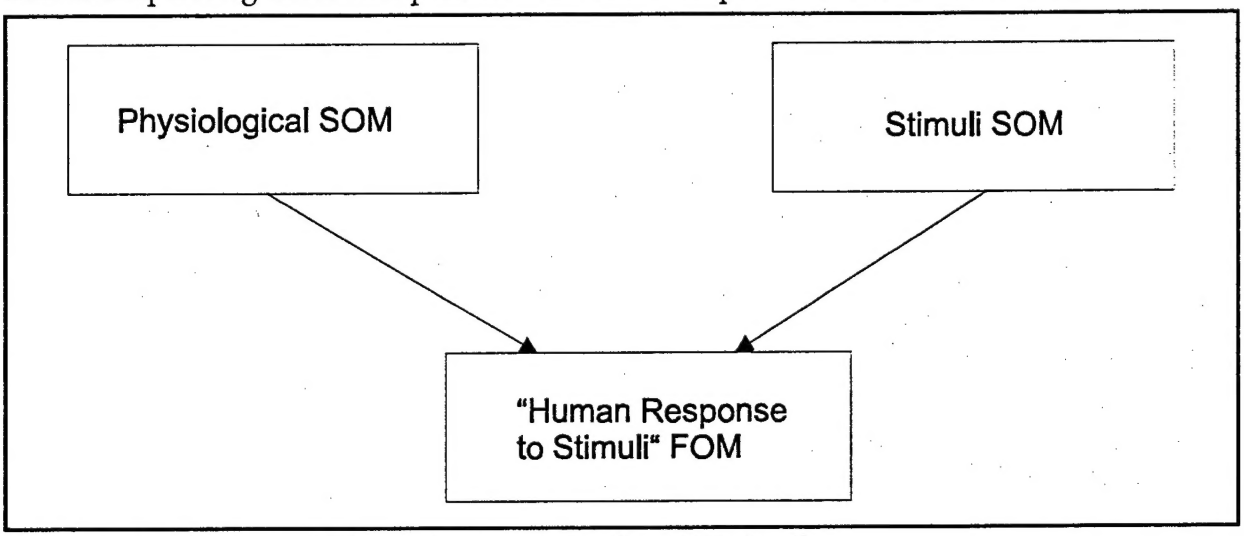

Figure 1. Architecture of "Human Response to Stimuli" Federation

Underscoring the theoretical nature of Phase I is the nature of the deliverables in this phase. They include the development of separate simulation object models (SOM's) for both the stimuli simulation and the physiological simulation. The development of such object models precedes any code development for the respective simulations. (The code development segment was planned for Phase II.) Also included is the development of the Federation Object Model (FOM) for a federation which involves the interoperating of the two simulations represented by the SOM's. Along with the FOM is a description of certain scenarios which illustrate the interoperation between the two simulations in the federation.

In addition to the work leading up to the deliverables for Phase I, some effort was directed towards looking into implementation issues and extensions. This involved the more generic issues of distributed simulation and effects on a running federation. Also, a possible extension/relationship of certain stimuli to environmental data was explored in the context of the state of the art environmental models.

A general discussion of the object-oriented methodology used in the development of the simulation object models (SOM's) is presented in Chapter 2. Although the High Level Architecture violates some of the standard object-oriented behavior and constructions, it incorporates others. The development of the Stimuli SOM and the Physiological SOM proceed without any legacy system giving guidance. In this situation, the object-oriented methodology is extremely helpful in guiding the development of the models (SOM's). The relevant techniques are presented in Chapter 2.

At the start, it was found that the conceptual space for the modeling segments of this project needed to be narrowed. A conceptual space, which would/should encompass the Stimuli modeling and the Physiological modeling, had to be developed. This was done without input from any legacy system or reference FOM, and is discussed in Chapter 2. However, the possible future need of a reference FOM is discussed in Chapter 6 (extensions). Finally, the process of developing the Object Model Templates from the HLA standpoint is presented.

The development of the Physiological simulation object model is addressed in Chapter 3. The rationale behind the development of the specific object classes is discussed. The role of attributes in communicating the modeling capabilities cannot be overstated. This chapter includes a discussion of the attributes, and the resulting functionality in the modeling. Interactions were identified through the use of event trace diagrams. Examples of these are presented prior to the subsection on interactions. The interactions of the Physiological SOM are covered in this Chapter. An additional section on "integration" of the modeling segments in the SOM was found to be necessary, and is included in this chapter.

Issues related to the development of the Stimuli SOM are covered in Chapter 4. These include the fundamental issue of scalabilty that arises in the discussion of the boundary between the stimuli simulation and the physiological simulation. This involves how much information the stimuli SOM has or should have, how much it should acquire, and what quantities it should be responsible for calculating. The object identification process is presented. It is in the discussion of the "Informational Attributes" that the linkage of the stimuli to the recipient human physiological system is developed. This chapter also addresses the case of "simple" versus "complex" stimuli. It is the cases of simple stimuli which are developed in the Stimuli SOM. A discussion as to how a future effort could incorporate complex stimuli is presented.

Chapter 5 presents the Federation Object Model for the intended federation: "Human Response to Stimuli". This object model template component is presented in two versions. These separate versions are motivated by separate views of what additional federates might participate in the "Human Response to Stimuli" federation. The scenarios for this federation are presented in Chapter 5. Through these scenarios, some of the simulation capabilities of the federation are made explicit.

Potential extensions to the Phase I effort are listed in Chapter 6. Part of the extensions center around the mannequin, and requirements of interfacing to HLA. During the course of this Phase I effort, it was found that a project involving the development of a "Medical Federation", which involved a mannequin, was already underway. Results from this project are referenced. Other extensions, not necessarily involving the mannequin, are presented.

From a usage standpoint, simulation applications of the Stimuli federate in the "Human Response to Stimuli" federation might involve interoperating with an environmental federate or a weather federate. One such example is given in Chapter 6. A possible usage for the "Human Response to Stimuli" federation might be as a link between the aggregated forces and the individual combatant. The physiological system could represent the state of the individual combatant.

Whether or not the mannequin (hardware) is in the (simulation) loop, the "Human Response to Stimuli" federation would most likely be run in a distributed manner for many applications. For example, educational applications, involving the virtual human physiological system, could be implemented in a distributed manner. The distributed network could be the Internet. In fact, distributed education over the internet has been cited as a future application. One such application could involve the effects of medical drugs as stimuli. Chapter 6 contains a brief discussion of distributed simulation issues and of the role of HLA in simulations. In order to develop the Physiological SOM to its fullest potential and to aid in identifying the new applications and potential users, it is suggested that the Physiological Reference FOM be developed. The discussion of HLA in the context of educational context is done in terms of the reference FOM.

1.2 Summary

The results of this project are the Object Model Template tables which are found in the Appendices. Note that the Object Model Template forms one of the components of the High Level Architecture (HLA). Simulations that are developed under the auspices of the Department of Defense are required to be HLA compliant. The tables which comprise a simulation object model (SOM) or a federal object model (FOM) are those in a standardized list defined in the Object Model Template specification document.

Prior to any software implementation of a simulation showing how the human body responds to certain stimuli, it is necessary to develop the theoretical models which give the simulation its structure. The human body may be represented by a mannequin, or it may be virtual. The network connecting the Stimuli federate, which is the software implementation of a stimuli generator, may be the Internet or it may be a local area network. This effort is concerned strictly with the development of the theoretical models, whose structure must be compatible with the Object Model Template structure. Of course, a consideration of future utilization plans and of implementation issues even at this theoretical development stage helps to not only set the bounds of the development but also results in a more robust development.

One of the first steps in the development of the theoretical models was to bound the simulation. A stimulus was defined to mean that which could evoke a physiological response from a human. This is clearly still too broad, so the parameters of the mission space were further tightened.

Ultimately, the selection of stimuli was confined to those which evoke a response from the respiratory system. In a similar manner, the modeling of the human body response was confined to the cardiovascular and respiratory systems (and supporting medulla centers). The factors involved in narrowing the focus of the conceptual space are discussed in Chapter 2.

During the course of this project, a Stimuli SOM, a Physiological SOM, and a "Human Response to Stimuli" FOM were developed. The Stimuli SOM and the Physiological SOM represent simulation object models which convey the nature of non-visual stimuli which affect the respiratory system, and the cardiovascular and respiratory systems in the human body, respectively. Each SOM contains object classes, attributes, interactions, and parameters which model its domain.

Object oriented techniques were used to elucidate the structure of the SOM's. Certain base classes in the Physiological SOM are organized according to mechanical engineering type classifications. The interactions, listed in the Interactions Table, of the Physiological SOM represent the events which take place between or among various of the objects. Such interactions model the physiological functions in the respiratory and cardiovascular systems.

Even though it is the smaller of the two SOM's developed in this effort, the development of a representation scheme for non-visual stimuli was quite challenging. Also at issue was the matter of where to demarcate physiological objects and stimuli objects. Should there be overlap in objects belonging to each of the SOM's? Recall that a stimulus is a stimulus precisely because it evokes a response from the body. This involved issues of scalability. Ultimately, a standardized representation for stimuli was developed, based upon "informational attributes". The complex datatypes feature of the Object Model Template was critical in developing these attributes. Moreover, consideration of the data structures led to the classification scheme of "simple" versus "complex" stimuli. Only simple stimuli are represented in the Stimuli SOM.

Two versions of the "Human Response to Stimuli" Federation Object Model were developed. (See the Appendices for details.) In the first version of the FOM, the physiological details are hidden. The second version of the FOM is essentially a union of the Stimuli SOM and the Physiological SOM. It is the second version which would be utilized in distance education applications. Scenarios to accompany the FOM were developed.

1.3 Conclusion

A number of technical issues arose during the course of simulation object model and federation object model development. These issues and the manner of their resolution are found in

abbreviated form in the preceding summary and in detail in appropriate chapters of this report. They are not repeated here.

The overall conclusion is that an HLA compliant software implementation of "Human Response to Stimuli" federation, based upon the FOM's which were produced in this work, can now be developed. This stimuli are restricted to the category of simple stimuli.

Chapter 2—Methodology used in the development of the Simulation Object Models (SOM's): General Comments

This chapter discusses the general methodology that was utilized in the development of the Simulation Object Models. Such a methodology was applied to both the Stimuli and Physiological SOM's. In brief, certain techniques from object-oriented development methodologies were utilized, subject to constraints imposed by the requirements and restrictions of the High Level Architecture (HLA).

The development of both SOM's has proceeded without input, or constraints, of any specific legacy system. In a typical usage, the "owners" of various simulations will, when developing a Federation Object Model , utilize the SOM to indicate the capabilities of their respective simulations. However, the SOM developments in this project have been done prior to any software implementation. Thus, both the Stimuli SOM and the Physiological SOM reflect the capabilities that are intended to be in a future software simulation implementation.

2.1 HLA Object Model Development

A recent paper by Lutz [1997] details the HLA object model development from a process point-of-view. This paper had as one of its stated goals "to suggest a generic, cookbook approach to the development of HLA object models". It is primarily assumed that the object classes are known, and merely have to be interrogated as to publishing capabilities and then cast into the correct framework in order to be HLA compliant. Of course, such a situation is not the case with either the Physiological SOM or the Stimuli SOM.

With regard to simulation object development, Lutz acknowledges that "having working software or even software design is not a prerequisite for SOM construction. In fact, completing a SOM prior to detailed simulation design is considered advantageous. ... Since, however, a SOM is intended to provide a specification of the *current* capabilities of a given simulation system, SOM's should not be made public until the functionality specified in the SOM has been fully instantiated. "The paper then proceeds to discuss determination of the Publishing Capabilities for the Object/Interaction Classes, under the unstated assumption the classes, which will be in the SOM, have been identified.

This is a very cogent and useful paper. It informed the process of hosting the Simulation Object Models in the HLA compliant Object Model Template format, and offered insight into the component structures of the Object Model Template. (We discuss this in the last sub-section of this chapter.) However, there is a missing segment in the development of the Simulation Object Models

from first considerations. This missing segment pertains to the exploration of the conceptual space in which the Simulation Object Models should reside.

2.2 Conceptual Space of the Simulation Object Models

In the development of both the Stimuli SOM and the Physiological SOM, the domain in which the simulations were to be developed had to be defined. Although the development of both Simulation Object Models in a parallel manner without any restrictions imposed by legacy simulations, allows one to maximize the logical inter-connections between the simulations, it also requires that initial attention be given to the conceptual space in which the simulations will reside.

The envelope of conceptual space of the Physiological SOM is the human body and its functioning. The focus is on the functioning of the human body as represented by (an eventual Phase II implementation of) the Physiological SOM. The respiratory and cardiovascular systems were chosen to be represented in the Physiological SOM. (Other systems can be included in an extensible manner should the need arise.) In addition, the areas of the brain which govern these systems (in the medulla) were included. Several reasons motivated this selection. First, the basic systems of the body are the respiratory and the cardiovascular systems. The body cannot exist for even one sixth of an hour without oxygen, a far shorter time period than it can do without water or food. Secondly, there are stimuli of interest whose primary effect acts on these systems directly or indirectly. Such stimuli include smoke, noxious gases, and particulates. These stimuli also exist in the conceptual space defining war-fighter activity. Finally, commercially available mannequins, which simulate human patient behavior, have modeled primarily these systems.

That is not to say that the Physiological SOM development is tied to any specific mannequin hardware. Rather, the Physiological SOM was designed without restriction to any mannequin hardware. Serious attention was given to include, in the attributes the quantities which are needed by the mannequin. A telephone discussion was held with the chief engineer at M.E.T.I., and key quantities were identified. Since the mannequin will respond to inputs from clinical monitors, the incorporation of relevant clinical quantities, as attributes in the Physiological SOM, became vital.

The Physiological SOM goes beyond the mannequin requirements into the realm of the "virtual patient". That is, the physiological details of the human respiratory and cardiovascular systems have been captured in the SOM. Specific discussions of the level of resolution selected and issues of fidelity are deferred until the chapter specifically pertaining to the Physiological SOM. For purposes of distributed simulation and distance learning, a software implementation of the Physiological SOM, which represents a "virtual patient" (planned for Phase II), would be quite useful.

Selection of a focal point for the development of the Stimuli SOM has been guided by the viewpoint that a stimulus is that which evokes a response in the human body. Of the universe of possible stimuli, the focus is narrowed to those which affect the human body. It is further narrowed to a set of stimuli which can affect the respiratory and cardiovascular systems

2.3 Simulation Object Model Limitations

Note that the SOM's are not a software design document. All the information necessary to construct a valid software implementation, reflecting the SOM capabilities, is not present. Missing is the set of information on which objects utilize information published by other objects. While in some simulations this might be deduced at first glance, this is not the case in situations where the simulation in question models very technical systems. Also, any system whose overall behavior is the product of interacting subsystems will likely evidence a level of complexity beyond what can be deduced by a listing of individual object classes and objects.

2.4 Object-Oriented Techniques Utilized in the Simulation Object Model Development; Subject to HLA Restrictions

There exist a number of standardized approaches to developing an object-oriented representation of a designated system. Implicit in the design of an object-oriented representation of a system is the ultimate intent to implement the system in software, most probably using an object-oriented language such as C++ or Smalltalk.

The last dozen years has seen an explosion in object-oriented analysis and design methodologies. Various approaches have been detailed in Coad and Yourdon[1991], Coad, North, and Mayfield [1995], Martin and Odell[1996], Rumbaugh, Blaha, Premerlani, Eddy, and Lorenzen [1991], and Shlear and Mellor [1989]. Fowler [1997], points out that many of the object-oriented design methods in use throughout the last decade have a large degree of commonality, although with a number of "annoying minor differences among them". Such differences carried over into the notation uses various systems. Notation is now on the verge of standardization via the Unified Modeling Language (UML). This modeling language is a graphical notation which communicates the object-oriented design. The upcoming standardization does not standardize the process to achieve an object-oriented design. Each of the object-oriented methodologies, referenced above, to achieve such a design for a system of interest.

A question arises as to which object-oriented design methodologies would be most helpful in developing the Simulation Object Models. A follow up question arises concerning how to communicate the ultimate design graphically (i.e., which "modeling language" to use).

The High Level Architecture is not strictly objected oriented. In particular, multiple inheritance is prohibited. Even more striking is the absence of methods, which are at the heart of the message passing paradigm of object-oriented systems. In HLA, the message passing is manifested through interactions and publish/subscribe relationships. The information needed by a particular object is mediated by the Federate to which the object belongs (via subscription).

In view of the fact that the High Level Architecture is not isomorphic to modern object-oriented systems, the decision was made to select a non-rigid design guide in assisting with the object development for the SOM's. To this end, the approach of Lee and Tepfenhart, as described in their recent book [1997], *UML and C++: A Practical Guide to Object-Oriented Development*, was selected. This work discusses in a unified, comparative manner the existing processes for the object-oriented design of a system. The strengths and weakness of the different processes are explored. As might be inferred, this text is non-dogmatic. While notation is clear, and graphical representations are explained, they do not follow the UML notation. We adopt this same approach.

We end this chapter with a brief discussion of those object-oriented design techniques which we found to be most helpful in developing the Physiological Simulation Object Model and the Stimuli Simulation Object Model. In the next two chapters, the application of these techniques to the subject matter domain are made more explicit, and the results of these processes are detailed.

With regard to the identification of objects, there are several techniques that are currently commonly practiced. These include:

(1) using the "entities to be modeled",
(2) using the definitions of objects in the subject matter domain,
(3) using generalizations,
(4) using object decomposition, and
(5) using subclasses.

In the last method, the object identification step is skipped in favor of immediate class identification. Techniques (1) through (3) were those predominantly employed to identify objects in both Simulation Object Models which were developed. The use of generalizations also helped to organize the class structure.

Object decomposition was found to be quite helpful in elucidating the aggregations. Aggregations are a particular type of relationship. The Object Model Template tool recognizes the importance of this particular relationship type and provides for the documentation of aggregations through the use of a "Components" table. (Other relationships between or among objects can be documented in the Associations table of the tool.)

The fifth technique seemed to pre-suppose part of the organizational structure which we were attempting to construct. It was not employed in the SOM development process.

While these techniques are the most current, Lee and Tepfenhart [1997] also document several traditional techniques, including:

(1) the use of Nouns to identify objects,
(2) interactive dialog with a domain expert in order to uncover the underlying "mental models" operating in the domain, and
(3) use of the "things to be modeled". Identification of "things to be modeled" was aided by the use of the category approach described by Shlaer and Mellor [1989], in which incidents, roles, interactions, specifications, etc. are investigated as possible sources of objects. All these traditional techniques were employed in the service of object identification during the course of the SOM development. The subject matter expert, Dr. Dale Birke, of the Department of Pharmacology and Toxicology at the West Virginia University Medical School also assisted in object identification.

The behavior of the system(s) represented by the Physiological SOM must also be elucidated. The issue of how this behavior is represented within the format of the HLA is postponed until the chapter on the Physiological Simulation Object Model. There are several techniques used in object-oriented analysis which help uncover and represent the static behavior of the system. Moreover, an investigation into the behavior of the system provides feedback as to the appropriateness of the objects which were identified.

The identification of "services" is as important as the specification of the objects in object oriented design. However, there are no services per se in the High Level Architecture specification. Rather, the HLA has a set of interactions in addition to the publish/subscribe capabilities of objects. Parameters can be associated with the interactions. This maps to the "signature" of a service in object-oriented design. In object-oriented design, the services provide the description of the static behavior.

Although services are not part of the HLA, there is still a need to identify the static behavior of the physiological systems and the stimuli. This identification is done via an event list. The internal and external events to which the physiological system is required to respond are listed. Internal events in the physiological system would be those which are specified, in the HLA manner, within the Physiological SOM. An external event which affects the physiological systems could be generated from some stimulus. Such external events would be documented in the Physiological System-Stimuli Federation Object Model (FOM). Of course, this list can always be extended; in a sense this is an open-ended task. The process of listing such events proves extremely useful in focusing the practical scope of the Simulation Object Models.

Associated with the event list is the Event Trace Diagram (named a Sequence Diagram in UML). In such a diagram, the events happen between objects, with time continuing to advance. Thus, activities within the system are described as events taking place in time, initiated by an object, directed towards a recipient object, which may in turn become an initiating object. These events serve to map out scenarios for the system, thus illustrating and describing system behavior.

2.5 Object Model Template Component Considerations

The first stage in "filling out" the object model template for a simulation object model requires the object classes and the interaction classes. The determination of this information is the subject matter of Chapters 3 and 4. However, if we assume that we have determined such classes, we can make certain general statements involving publication and subscription. Note that the Object Model Template is the "standard presentation format and content for both the FOM and SOM's" [Lutz, 1997].

Publication and subscription services constitute the heart of the HLA simulation communication architecture. Within a Simulation Object Model, the publication of attributes of an object is intended to clarify the modeling capabilities supported by the simulation and connected with the object class. Moreover, the interactions within a simulation elucidate the intra-simulation communication among the objects. This intra-simulation communication is an indicator of the capabilities of the application level simulation modeling. Even though the attributes of objects are to be published, it is the object class which is designated publishable according to the HLA rules.

Let us consider the situation within the Physiological SOM. The interactions in that SOM are of no interest to the Stimuli SOM, since the stimuli are unaffected by a recipient body. Why should they be specified within the HLA framework? Again, it is necessary to consider the conceptual space in which the Physiological SOM is being developed. For example, it may be the case that the Physiological SOM, will at some point later in time be utilized in a Medical Training Federation which may be distributed. Consider a student or trainee learning respiratory technology. The role of the Physiological Federate could be to provide a "virtual patient" with cardio-pulmonary capabilities. The student/trainee could interact with the "virtual patient" simulation via a "Student/Trainee Federate" which allows the student access to the virtual patient.

Such a Medical Training Federation would be dual-use (DoD and non-DoD), and could be a product involving distributed training. From a cost and resource standpoint, such a Medical Training Federation would be very attractive. In order for a Medical Training Federation to know the modeling capabilities (functionality) of the "virtual patient", the interactions and publish/subscribe (object class) information must be present in the Physiological SOM.

The Simulation Object Model should also indicate the types of data that it must import or would be able to use (reflect) if it did import from other simulations. For example, the present Physiological SOM effort does not include detailed internal kidney function capabilities. In a future Medical Training Federation, the internal kidney functionality might be provided by a specialized Kidney Federate. The Virtual Patient Federate could then import and reflect certain key attributes connected with the Virtual Patient's lumped kidney tissue, which were calculated by the Kidney Federate. The "Student Trainee Federate" would then be the third member in the Medical Training Federation, but might not interact directly with the Kidney Federate.

The object class attributes, the parameters in the interactions, and the interactions that convey the capabilities of a simulation via its SOM. The chapters on Physiological SOM and Stimuli SOM development discuss such quantities in detail.

An additional feature provided by the Extensions to the Object Model Template is the Associations Table. In the Physiological SOM in particular, the Associations Table allows one to capture information on "co-operative" physiological features. One of the limitations of the Object Model Template is the lack of specificity as to where subscription information will be utilized; i.e., what objects will use what information to update which attributes? We attempt to convey this information, in a general manner, via the Associations Table.

The development of the Object Model Template to convey the Physiological SOM, Stimuli SOM, and FOM information was greatly facilitated by the use of the OMT Tool; see Lutz et al [1996].

Chapter 3—Development of the Physiological Simulation Object Model

The goal of this chapter is to populate the Physiological Simulation Object Model (SOM). As this is being done prior to any implementation in software rather than afterwards, as would be the case with a legacy code, the question of the cconceptual space of the Physiological SOM is crucial. Once this is decided upon, object-oriented techniques can be utilized to aid in the identification of objects and events. The objects and objects classes will map into the HLA format i.e., the Object Model Template, as long as multiple inheritance is not permitted. The physiological events help structure the interactions according to the HLA format. The Object Model Development Tool is utilized to prepare the Simulation Object Model. This allows the SOM information to be captured in a standardized set of tables, moreover, the tool provides certain consistency checking features that would not be provided in, for example, a standard spreadsheet environment.

3.1 Conceptual Space of Physiological SOM

As was discussed in Chapter 2, the boundaries of the conceptual space of the Physiological SOM narrow the range of objects, services, and activities of the system which must be captured. The Physiological SOM conceptual space is narrowed to the respiratory and cardiovascular systems. The parts of the medulla, involved in regulating these systems, are included. Also included are the transmission fibers (nerves) that conduct signals from the system components to the regulatory centers in the brain.

The wealth and variety of physiological behavior makes it a necessity to limit the scope of the SOM conceptual space. Our decision to limit the scope to the respiratory and cardiovascular systems is based on their key involvement in the intake and distribution of oxygen, which is essential to the life of the physiological system. Without these systems there can be no simulation of any physiological activity. Note that the basic systems of the human patient simulators (mannequins), offered by both M.E.T.I. and Eagle Simulation, include the respiratory and cardiovascular systems.

With regard to the relevance of these systems to the ultimate goal of modeling the human response to stimuli, it is noted that many stimuli target the respiratory system. From a military applications viewpoint, certain stimuli found in battlefield conditions, such as smoke, particulate matter, various gases, and toxic vapor clouds , target the respiratory system. From a dual-use perspective, various applications such as anesthesiology involve stimuli which involve the respiratory system. There will be no difficulty populating a Simulation Object Model with stimuli that affect the functioning of the human respiratory system.

3.2 Clinical Focus and Level of Resolution

Even with the focus of the Physiological SOM narrowed to incorporate only the cardiovascular and respiratory systems, along with related functionality in the brain/nervous system, there are still decisions to be made regarding the approach and the level of resolution.

A functional approach, based on physiology, was adopted for the modeling. This is in contrast to a strictly anatomical approach which would have involved a listing of the anatomical features of the cardiovascular and respiratory systems. The physiological approach highlights the behavior of the body systems. With the behavior comes the need for measurements of physiological performance. This brings in the notion of "clinical" quantities: those quantities which are measurable and are useful for describing the state of a patient. It is also noted that clinical quantities are used in the simulation of breathing, etc., by the hardware mannequins.

The choice of a physiological/functional approach assists in resolving other the issues involved in modeling the respiratory and cardiovascular systems. In particular, the issue of the appropriate modeling level of resolution must be determined.

If a strictly anatomical view-point held sway, then the lowest level of instantiated object would be at the cellular level. The focus on the cardiovascular—respiratory systems in this effort would require that blood cells be instantiated; since delivery of oxygen to the body organs and tissues would be accomplished via blood circulation, with the appropriate gas exchange mechanisms occurring. Let us investigate the ramifications that a decision to adopt the strictly anatomical view-point and model at the lowest anatomical level involved in the physiological functioning would have on the modeling effort.

Blood cells are examples of connective tissues, in which the cells are embedded in an extra-cellular matrix. In the case of blood cells, this surrounding matrix is fluid. There are several types of cells found in this matrix. One specific type, the erythrocyte, transports oxygen. Erythrocytes are biconcave disks, lacking a cell nucleus, which are 7-8 microns in diameter. A figure of merit for the number of erythrocytes contained in the adult circulatory system is 25 trillion. Moreover, the life cycle of these cells involves the destruction of approximately 2.5 million old cells per second, and the creation of an equal number of new cells. Even if the erythrocytes were considered to be in steady state, there are still far too many single cells to instantiate as objects. This level of resolution is not workable.

Information on oxygen and carbon dioxide transport is needed in order to model the functioning of the human respiratory and cardiovascular systems. The goal of the modeling effort is to simulate the physiological functioning rather than to capture the lowest levels of biological detail. This goal

can be realized with a level of resolution that is at the tissue group level. The tissue groups will have their respective oxygen demands and will output their respective amounts of waste gas (carbon dioxide) which must be accounted for in the physiological modeling. Moreover, the figures of merit for tissue oxygen usage and waste gas production are clinical quantities which involves a certain amount of lumping together of some anatomically distinct tissues.

The object set and the classes developed for the Physiological SOM reflect the decision to adopt a functional viewpoint and to model at the tissue level of organization. In addition, the object classes include certain elements which are functional representations rather than anatomical structures.

3.3 Object Identification and Class Structure

The identification of objects and the development of the class structure for the Physiological SOM did *not* proceed in isolation from the scenario development described by the Event Trace Diagrams (in subsection 3.5). However, the starting point for the object identification was a consideration of anatomical structures subject to the constraint of a functional representation. The objects which proceed from such considerations is the focal point of this subsection.

Any development of the objects and class structure that is acceptable for the SOM is non-unique. Therefore, the content of this subsection includes the motivation behind the selections as well as a presentation of the objects and class structure themselves. For a complete listing of the tables in the Physiological SOM, see Appendix A.

The methodology adopted in initiating this effort was: (1) engage the subject matter expert (SME) in a discussion regarding the requirements, (2) to follow up independently on the subject matter utilizing several functionally oriented references, and (3) to re-engage the subject matter expert, posing questions that originate from the first report of the SME and also from independent investigations. This cycle was in use throughout the life of the Physiological SOM development, and culminated with a review of the entire completed SOM by the subject matter expert. The final review focused upon the completeness of the objects, attribute set, interactions, and parameters in describing the physiological activities of the cardio-respiratory system in the presence of selected stimuli.

Functionally oriented references included an undergraduate, college level anatomy and physiology text [Seeley et al, 1992], an anatomy text used in medical schools [Agur, and Lee, 1991], and two monographs which involved mathematical fluid mechanics and engineering perspectives on the circulatory and respiratory systems [Rubinow, 1973; Lighthill, 1975].

A perusal of the Physiological SOM (Appendix A) reveals that there is depth to the class structure. A depth of 3 to 4 is not uncommon. The base classes are given by the following table, Table I.

Table I. Base Class Structure: Physiological SOM

OrganicDuctwork
Organs
OrganicRCPTRS
TissueGroups
Cavities
Chambers
Valves
LumpedZones
Human
MedullaReceiveComputeSend
CardiovascularSystem
RespiratorySystem
BodyEnvironMatrix

An excerpt of the subclass structure of the Physiological SOM is presented in Table II.

Table II. Excerpt of sub-class structure in the Physiological SOM.
Class 1 indicates the Base class.

Organs	Heart (PS)	
	Lungs (PS)	
OrganicRCPTRS	ChemoReceptor	CO2Sensor
		PHSensor
		O2Sensor
	BaroReceptor	BAROAorticArch (PS)
		BAROCarotidSinus (PS)
	IrritantSensor	AveolarIrritantSensor (PS)
		BronchioleIrritantSensor (PS)
		LarynxIrritantSensor (PS)
		TrachealIrritantSensor (PS)

TissueGroups	UpperLimbTissue (PS)	
	HeadNeckSpineTissue (PS)	
	LowerLimbTissue (PS)	
	IntilliacViscNParietTissue (PS)	
	AbdomVisceraTissue (PS)	
	KidneyTissue (PS)	
	HeartTissue (PS)	
	EsophagusTissue (PS)	
	LungTissue (PS)	
	Respiratory Muscles	Abdominal (PS)
		ExternalIntercostals (PS)
		InternalIntercostals (PS)
		Diaphragm (PS)
Cavities	NasalCavity (PS)	
	ThoracicCavity (PS)	

The object base classes can be logically divided into several categories. Rather than state what these are at the outset, the nature of the base classes will be considered after their respective development has been discussed in detail.

One of the object-oriented analysis techniques that proved quite fruitful in the task of identifying objects was generalization. Several object base classes provide a basic mechanical function. Such base classes are a mechanical engineering viewpoint of the body components which are needed to provide the functionality for the respiratory-cardiovascular systems. One example is the "Organic Ductwork" base class, which has the sub-classes of: (1) respiratory ductwork, (2) cardiovascular ductwork, and (3) nervous ductwork. In a similar vein, the base classes of chambers, valves, and cavities, and organic receptors (sensors) are generalizations from a functional, mechanical engineering viewpoint of the necessary component objects involved in cardio-respiratory functions.

The issue of resolution impacts the development of these "mechanical" base classes. How deep should the subclass structure be? How wide should a given subclass level be? Take the case of the subclass "Cardiovascular Ductwork" (Class 2 in the OMT specification) . Proceeding to the next subclass level (Class 3), we find "Artery in Body", "Aorta", and "Vein in Body". What is not listed is the subclass "Capillary", which is below the level of resolution selected. The specific arteries, aorta subclasses, and veins that appear in Class 4 are the major conduits for conveying the "blood

constituents", through the body, from the heart to the recipient tissue groups, returning for re-oxygenation, and then re-circulated. Through a proper choice of attributes, the circulatory system's involvement in the respiratory process can be captured. The details of oxygen usage by the tissue groups is done in a "lumped manner" which will be discussed later in this subsection.

Although the "Organic RCPTRS" object base class was defined, and its subclasses structured using the mechanical engineering generalization, the existence of the corresponding anatomical entities and their role in the respiratory process became known via the objects which take place in the event (or scenario) of normal breathing.

The base classes which map most closely to recognizable anatomical features are Tissue Groups and Organs. The respective subclasses of these base classes include only the objects which play a role in the respiratory and associated cardiovascular processes. For example, the subclasses of the Organ base class include Heart and Lung.

The identification of the Tissue Groups and Organ object base classes was done via a consideration of the anatomical objects, i.e., through a consideration of the "entities to be modeled ", the objects themselves. Development of the object subclasses came about by restricting object membership to those having a role in respiration. The oxygen usage by the subclass members of the Tissue Groups that would be instantiated (e.g., Heart Tissue, Lung Tissue, etc.) is done in a lumped manner via a selection of the attributes. It is the attributes which really delineate the functionality that is present. This will be discussed further in the next subsection.

The "Lumped Zones" base class represents those classes which involve some sort of merging or "lumping" of various anatomical features and physiological processes for the purpose of calculation. The results of this calculation may yield a clinical quantity rather than an in vivo physiological quantity. In the Physiological SOM, there are two subclasses of this base class, both of which pertain to the respiratory system. These are the Conducting Zone (of the lung) and the Respiratory Zone (of the lung). These subclasses are an idealization of the features and processes found in the lung and its associated airway passages. This idealization originated in a medical and clinical context, given impetus by the need to perform calculations which could then be related to measurable quantities which themselves would give an indication of the health and proper functioning of an individual. Thus, the Lumped Zone object class identification proceeded from knowledge of how the domain was organized by medical experts. (This information was provided by the medical consultant.)

Consider the Respiratory Zone subclass. It is the idealized region in which the gas exchange mechanism necessary for re-oxygenation of the blood takes place. From a strictly anatomical viewpoint, the gas exchange occurs across a respiratory membrane, which is composed of six layers

found in the bronchioles, aveolar ducts, and aveoli. There are approximately 300 million of the respiratory membrane unit. It is not feasible to instantiate 300 million respiratory membranes, calculate the physical diffusion processes across each of the membranes, and then connect the membranes via a capillary network. Note that the aveoli, aveolar ducts, and capillaries are below the level of resolution determined for this effort. Moreover, it is not necessary to descend to this level of anatomical and physical process resolution when the quantities of interest are at a more macroscopic level. Thus, attributes such as an average membrane thickness and a total membrane surface area, are used in the calculation of the gas exchange process.

The object identification process revealed more than one appropriate base class from which lung functionality. There is a "Lung" subclass of the Organ base class which essentially models the lung anatomical features as they pertain to the process of breathing, as well as the clinical quantities associated with the lung organ in the process of breathing. Attributes of this subclass include anatomical quantities such as lung compliance. Also included as attributes in this subclass are lung volume, internal lung pressure, etc. The more overtly clinical quantities include inspiratory reserve volume, lung capacity, etc. For example, lung capacity is measured with a spirometer, and the resulting value is used clinically. This is in contrast to the attributes of the Lung Respiratory Zone which are necessary to calculate quantities associated with the physical process of diffusion in the physiological process of re-oxygenation.

The category approach of Shlear and Mellor, which considered interactions, was also useful in the object identification process. Analysis of the interactions necessary for normal respiration captured the Lung Tissue subclass of the Tissue Groups base class. In a similar manner, a consideration of the Heart function in the context of normal respiration yielded a number of important objects in the subclasses. Also note the subclass of "Heart Tissue" derived from the Tissue Groups base class. A review of the circulatory cycle in the re-oxygenation process led to the development of the "Heart Chamber" and "Heart Valves" subclasses.

The "Epiglottis" base class is somewhat unique; it was identified from the Event Trace Diagrams as a missing object.

The base classes of "Respiratory System" and "Cardiovascular System" were included in order to make explicit the functionality inherent in the Physiological SOM, and to allow other potential SOM's to view these as base classes in potential interactions, etc. The intended functionality of these two base classes is communicated by their structure; it is the "Components" section of these objects (see the OMT structure) which are richly filled-out.

The "Human" base class was included so that certain characteristics, which have some impact on the respiratory system but which are not truly related to the other objects, can be included.

Although there are no subclasses, such characteristics are included via the attributes of this base class.

The "Medulla Receive Compute Send" base class contains the regulatory structure of the medulla which controls the behavior and integration of the respiratory and cardiovascular systems. The subclasses delineate the various control centers which have been functionally identified (physiologically). It is noted that, anatomically, a control center might be a number of cells co-located in a region of the medulla oblongata.

The final object base class of the Physiology SOM is the "BodyEnvironMatrix". This is the class which will interact with the stimuli. Any initial processing of the stimuli by the body will occur in the software implementation of this base class. The scalable approach, which was adopted, is the body (software implementation of the Physiological SOM) is responsible for calculating and updating its state after receipt of the stimuli. The stimuli can not know exactly what state the body is in; *they cannot know precisely what its effect will be at precisely what time.* For example, if the body is wearing protective gear when a vapor cloud is the stimulus, the body response might not involve any damage to the lungs, etc. However, a stimulus does package detailed information as to the nominal parameters of the interaction. This is part of the crux of the Stimuli SOM development, and is discussed in Chapter 4.

3.4 Attributes

Attributes, associated with objects, best serve to delineate the capabilities of the model within the context of the OMT. The semantics of the attribute are conveyed via the lexicon. In order to fully characterize an attribute, additional characteristics beyond the name, object class identification, and lexicon, are mandatory. These include a listing of the datatype, cardinality, units, resolution, accuracy, accuracy condition, update type, update rate/condition, whether the attribute is transferable or acceptable, and whether it is updateable/reflectable.

This section contains a presentation of attributes of several of the objects which constitute the Physiological SOM. Note that use has been made of inheritance wherever possible. Rather than exhaustively list all of the attributes (and definitions) which constitute the Physiological SOM, the discussion will focus upon the usage and relationship of attributes in the different object classes, and their role in the modeling.

An excerpt of the attributes list in the Physiological SOM is given in Table III.

Table III. Excerpt of the Attributes List in the Physiological SOM. Only the attribute names are listed.

Heart	HeartRate
	StrokeVolume
	CardiacOutput
	PeripheralResistanceTotal
	ForceOfContraction
	BloodPressure
IrritantSensor	Location
	Status
TissueGroups	MetabolicRate
	pCO2Waste
	pO2Demand
	PeripheralResistance
	O2ExtractionCoefficient
	PercentCardiacOutput
	pO2ofTissueGrp
Human	HemoglobinBindingPercent
	Age
	Weight
	Temperature
	HumanState
	ShuntFactor
ArteryinBody	pO2In
	FlowRate
	Diameter
	pCO2In
Aorta	pCO2In
	pCO2In
	FlowRate
	Diameter

The Heart object is concerned with the pumping of blood; the attributes associated with this object include the Cardiac Output, Stroke Volume, and Blood Pressure. These attributes are all connected with the continuous pumping of blood through the circulatory system. Additional attributes associated with the Heart are those which enable the calculation of these key quantities.

Similarly, the Lung Object is concerned with the volume of air (gas) inhaled (or exhaled). Key attributes include the respiratory rate, lung volume, and lung capacity. Other attributes, such as internal lung pressure, are utilized in calculations. The key attributes for both the Heart and Lung objects involve many of the clinical quantities. Note that in the Lung Object, the respiratory rate is a calculated, rather than an imposed, value.

The question might arise as to how the circulatory system might function to deliver blood that has been oxygenated, and to collect blood for re-oxygenation when there is not a "blood" object. The answer lies in the attributes of the "Artery in Body", " Aorta", "Vein in Body", and "Tissue Groups". It is the conveyance of oxygen through the body to be used by the tissue groups, and the conveyance of carbon dioxide away from the tissue groups as waste which is of interest in the modeling. A virtual conduit has been set up through the existing object class structure involving the arteries, veins, and tissue groups. It is via the attributes that a virtual flow network is maintained. In support of this modeling, the "Artery in Body" and the "Aorta" classes have the attributes pO2In, pCO2In, flow rate, and diameter. It is the partial pressure of oxygen (pO2In) which indicates the oxygen that is being delivered through the conduit. (There is also a certain amount of CO2 always present.) In the "Veins in Body" object class, the attributes are pO2Out, pCO2out, flow rate, and diameter. That is, after the arteries have delivered the oxygen to the tissue groups, each tissue group has used a certain amount of what is available, and has passed along a certain amount of waste product in the form of a pCO2out. The "Tissue Groups" object include a metabolic rate, a pO2Demand, and a percent cardiac output which serve to describe the oxygen demand. The extraction coefficient is related to how much oxygen delivered by the artery diffuses through to the tissue. The peripheral resistance serves as a measure of efficiency. Ideally, the pO2 of the tissue would be maintained at its necessary level. If the metabolic rate increases, the pO2Demand increases, and the pO2 level of the tissue group drops before the cardiovascular and respiratory systems can make adjustments.

Information as to what arteries (veins) feed (drain) which tissue groups is located in the Associations Table of the OMT. This information is crucial to the actual implementation of the virtual patient/combatant/stimuli recipient. Also included in the Associations Table is a linkage between the nerves and tissue groups; i.e., specific nerves serve to relay information about the state of the tissue groups from the tissue group to the medulla regulatory centers regarding tissue distress. Specific nerves are instantiated as members of the subclass of Nervous Ductwork.

The regulatory centers in the medulla can act to remediate the tissue distress situation via artery constriction and dilation. Note that flow rate and diameter are two additional attributes of the "Artery in Body", "Aorta", and "Vein in Body" object classes. Moreover, the specification of the attributes at this class level allows for inheritance of these attributes by a specific instantiated artery or vein, thus simplifying the OMT tables and presentation.

One of the key attributes is the blood pressure, which is owned by the Heart. This is a reflection of the importance of blood pressure in maintaining homeostatis in the human body. The Physiological SOM must capture this cardio-respiratory interaction, including existence of warning sensors. This was done via the "Organic Receptor" object class. It is the subclasses of this object class, together with their attributes, which are central in helping to maintain the effective functioning of the cardio-respiratory systems. Note the attributes "BPChange" and "DirectionBP Change" in the barotropic (pressure) sensors located in the aortic arch and near the carotid sinus. These are instantiated as objects "BAROAorticArch" and "BAROCarotidSinus". Also, there are chemical sensors in the body, including oxygen sensors near the same locations as the pressure sensors. (Physically, these sensors are specialized cells.) The oxygen sensors (CarotO2Recpt and AorticO2Recpt) have pO2 as an attribute. Other attributes of the sensor are concerned with their "status" (functioning or not), and the reporting of their "location", which is fixed.

The respiratory system is concerned with the intake of oxygen, the expulsion of carbon dioxide, and the re-oxygenation of the "blood" that is "carried" by the circulatory system. In addition, there are muscles of respiration which enter into the breathing sequence, along with control centers in the medulla, and the connection between certain nerves and respiratory system components. In the Physiological SOM, it is the respiratory system activities and interactions which primarily respond to the stimuli. The cardiovascular system enters because it is coupled in physiologically.

Therefore, it is expected the modeling of the respiratory system would be very detailed, and this is indeed the case. A discussion of the attributes in this subsection and the presentation of the objects in the previous subsection do not convey the depth of interaction for the respiratory system as well as they do for the cardiovascular system. For the complete picture, a detailed presentation of the interactions must also be performed. This will be done later in this chapter.

The attributes of the "Lung" object reflect its role as the major organ of respiration in the body. In the modeling effort, the behavior of the lungs (how inflated, what the respiratory rate is, etc.) comes about as a result of the dynamics. For example, there is *not* an imposition of a respiratory rate. Rather, this quantity should be calculated from the number of inhalations and exhalations that occur. This number should be different for normal breathing, for breathing under an imposed metabolic load (which could reflect exertion), and breathing in the presence of selected stimuli. The

requirements of the lung tissue, regarding its oxygen intake and carbon dioxide rejection, are modeled by the attributes of the "Lung Tissue" object , which is a "Tissue Group" object subclass.

Additional "Tissue Group" subclass objects are needed for their direct role in respiration. These are the "muscles of respiration", which include the "diaphragm, external intercostals, internal intercostals, and the abdominal" subclass (level 3) objects. The attribute which distinguishes them from other "Tissue Group" subclass objects is that of "contraction level". The contraction and relaxation of these muscles produces the volume change of the thoracic cavity, which is responsible for air movement in and out of the lungs. Note that the "Thoracic Cavity" object, which is a subclass of the "Cavities" object, has a volume as one of its attributes.

Gas exchange is necessary for re-oxygenation, which is expressed in the Physiological SOM as new values of pO2 and pCO2. This exchange is captured in the "Lung Respiratory Zone" subclass object through such attributes as "pO2staleBlood, pO2newBlood, pO2InspiredAir", etc. The anatomy of membrane size is captured through the "Membrane Surface Area" attribute. Both the "Membrane Thickness" and the "Aveolar Ventilation Rate" are attributes that capture the quality of the respiratory system in the gas exchange process. A thicker membrane implies more difficulty for the diffusion process, and thus less efficiency in the gas exchange mechanism. The effective membrane thickness increases when additional mucus is present. Certain stimuli affect the effective membrane thickness.

The attribute(s) of the respiratory ductwork sub-classes is simple, consisting of the "diameter". These subclasses include the Pharynx, Larynx, Trachea, and Bronchia. These can play a role in the calculation of the "Overall Airway Resistance", which is an attribute of the subclass "Lung Conducting Zone". A calculation of the "Overall Airway Resistance" would impact how much air was available from the inhalation. However, these subclasses are connected anatomically with another subclass, that of the "Irritant Sensors". The "Irritant Sensors" are cells which response to the presence of irritation due, for example, to particulate matter. They are found in areas of the respiratory system. The relationship between a specific subclass of the "Irritant Sensor" and its physical location within the respiratory system is given by the "Location" attribute of the specific (irritant-type) sensor, inherited from its parent class ("Irritant Sensor"). The Associations Table presents the relationship.

The attribute "status" appears in several of the (sub)classes. Its meaning is "On/Off" or "Open/Closed" or "Active/Quiescent". For example, the class "Epiglottis", which plays a role in coughing, can be open or closed. In contrast, this same attribute for an Irritant Sensor subclass would indicate whether or not the sensor was functioning properly. The precise semantics of "status" varies with the class context.

In what is a departure from the attributes of other classes (or subclasses), the attributes of the "Body Environ Matrix" pertain to the surrounding environment and act as an interface between the external stimuli and the virtual patient. These include attributes such as "external temp", "air components", etc. The attribute of "Body Affectors" is of unlimited cardinality, and one of the means of interfacing between the stimuli and the physiological subsystems. A discussion of the stimuli in the chapter on the Stimuli SOM will help elucidate this.

3.5 Event Trace Diagrams

An elucidation of events that occur in the human body in response to the introduction of stimuli, or as part of a nominal state, greatly aids in the identification of *objects* that will be utilized in the physiological simulation object model (SOM). A tool to represent such events is the *Event Trace Diagram.*

The event trace diagram is a representation of (segments of) scenarios. Examples of such scenarios include the sequence of respiratory system events which produce normal breathing, those which produce a "cough", etc. The scope of a scenario may be broad or it may be more limited in scope.

Consider the scenario in which a decrease in heart rate results from the actions taken by the cardioregulatory system in the medulla. Following a detection of the blood pressure rise by the carotid baroreceptor, the associated glossopharyneal nerve transmits this information to the cardioregulatory center. After any algorithmic calculations are performed, the vagus nerve is employed by this regulatory system to transmit information to the heart to decrease its "heart rate".

Event A is a stimulus from the Carotid Baroreceptor to the Glossopharyngeal Nerve noting that Blood Pressure has increased. Event B is a transmittal from that nerve to the Cardioregulatory center in the medulla that carries the message of increased blood pressure. After algorithmic activity, the center implements its decision in Event C by calling upon the Vagus Nerve to transmit a message to the Heart to decrease its "heart rate". The Heart is the final object in the event sequence, and it receives the message from the Vagus nerve in Event D.

Note that the events occur as time is increasing. Also, note that the events are anchored by objects. That is, an object initiates the scenario. All of the individual steps that lead up to the conclusion of the scenario are initiated by objects. Also, objects are the recipients of all the intermediate events.

In the context of HLA, some of these events are implemented as "Publishing" and some are implemented as "Interacting". In general, the implementation should utilize a " publish/subscribe" mode of communication if the activity is of a more continuous nature.

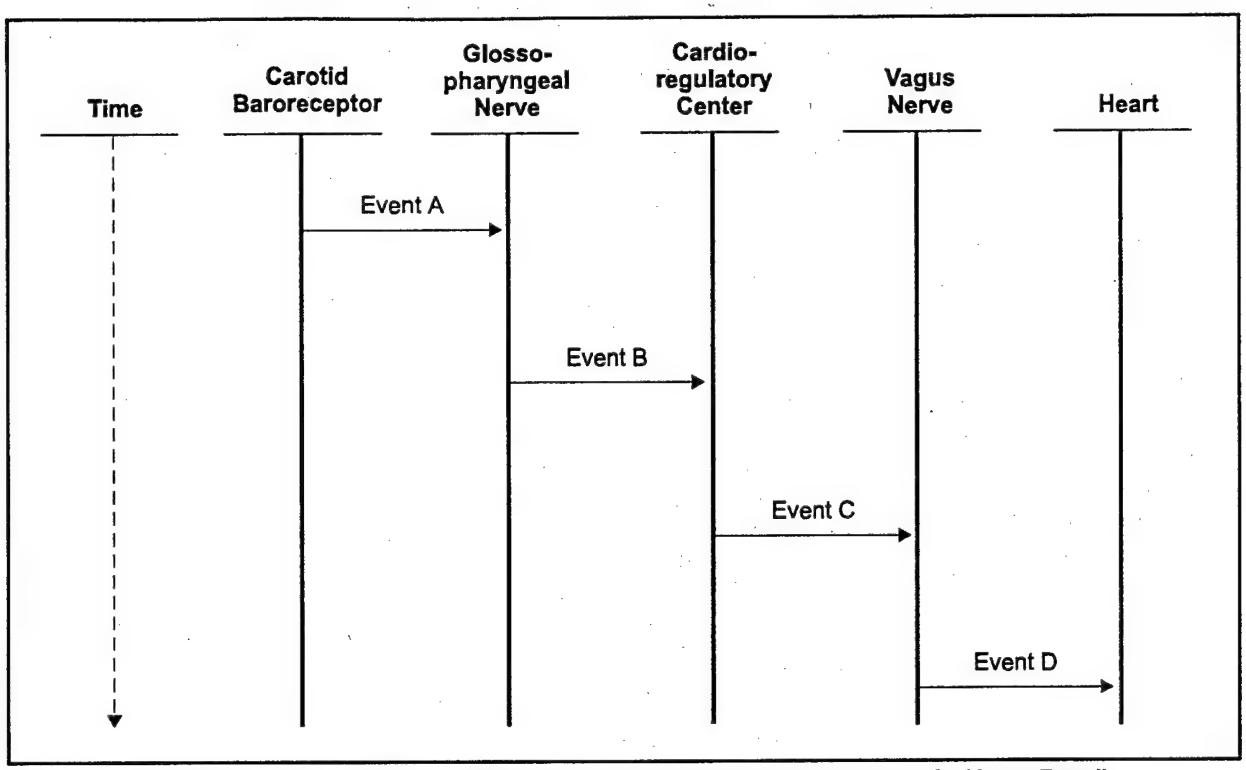

Figure 2. Event Trace Diagram for: "Blood Pressure Increase to Decrease in Heart Rate"

Construction of event trace diagrams is an object-oriented technique which aids in the identification of objects. However, these diagrams have proven useful in organizing the expert knowledge obtained from the medical consultant. Several more event trace diagrams will be presented in this section in order to illustrate the usage of the physiological objects and the nature of their standard activities. Of course, for a more complete view, this section should be taken in conjunction with the Interactions subsection of this chapter, the section in Chapter 5 involving the scenarios, and the object model tables themselves.

Prior to the " Low Oxygen Levels from the Carotid Oxygen Sensor" event delineated on the next page, the carotid oxygen sensor object senses that pO2 is "low". It publishes this situation. The glossopharyngeal nerve is "listening to " the carotid oxygen sensor, and sends this information to the medulla cardio regulatory object. This is Event A. The cardio regulatory object takes action upon obtaining this message, but the action that it takes depends upon the results of calculations in conjunction with other information it has received. One of two possible messages are transmitted in Event B. Notice that the recipient object, the Vagus Nerve, receives both messages. The Heart object is the recipient of the transmitted message (interaction) from the Vagus nerve object. This transmission is Event C. The Heart object is told to either increase or decrease the heart rate (an attribute), depending upon which message was transmitted.

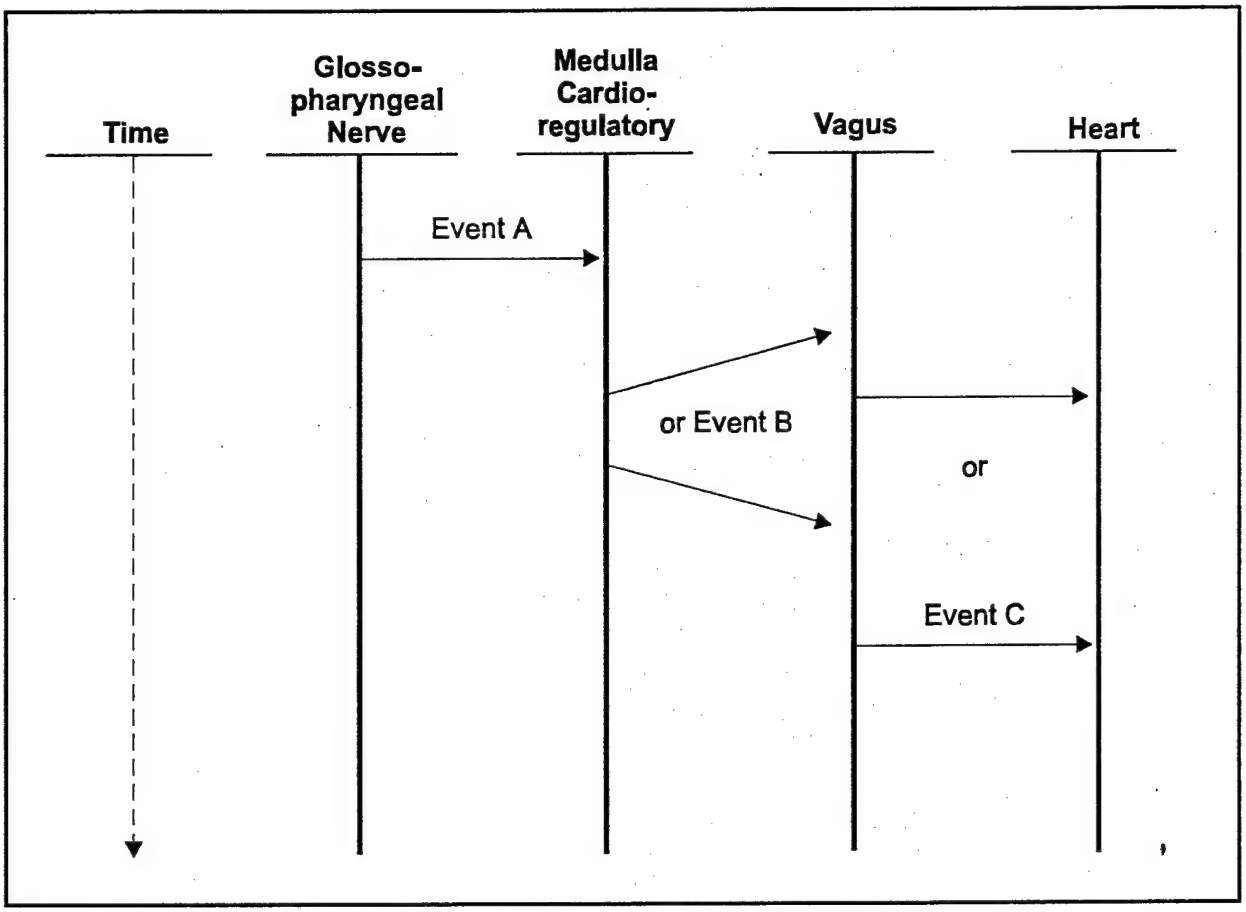

Figure 3. Event Trace Diagram for: "Low Oxygen Levels from Carotid O2 Sensor"

In the next event, termed the "Response to Irritant" event, the "Bronchiole Irritant Sensor" is alerted to the presence of an irritant. Such an irritant could arise from particulate matter in a particle cloud associated with battlefield smoke. The local response of the irritant sensor is given in this event trace diagram. Physiologically, this local response is a histamine release. This has the effect of constricting the air passageways in the bronchia. This activity is what is modeled in the above diagram. Event A is a "constrict bronchia" message. This is incorporated into the Object Model Template as an interaction.

The presence of an irritant in the bronchia region causes other events in addition to the local release of histamine. It also induces the "Cough Sequence". This sequence of events involves respiration regulatory centers in the medulla, as well as muscles of respiration, lungs, epiglottis, and the nerves involved in transmission. A segment of the "Cough Sequence" is presented in the next figure. This is only a partial sequence. The entire sequence is discussed in the Interactions subsection.

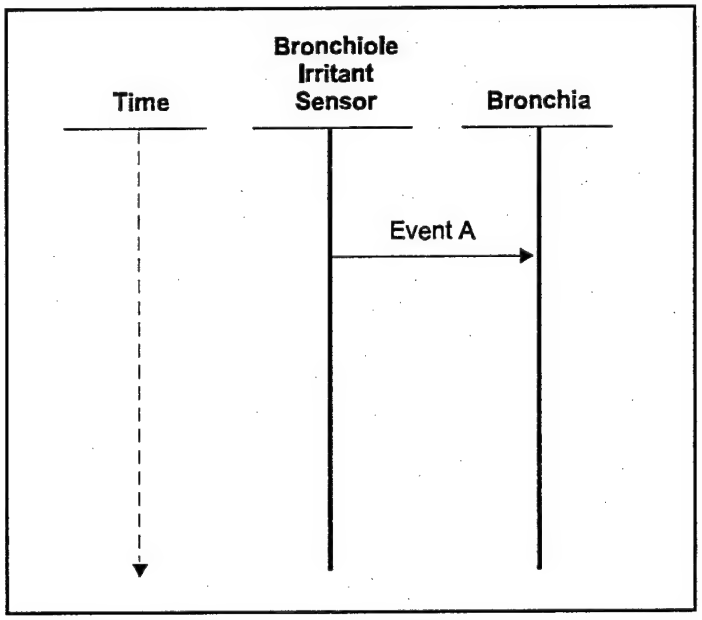

Figure 4. Event Trace Diagram for: "Response to Irritant"

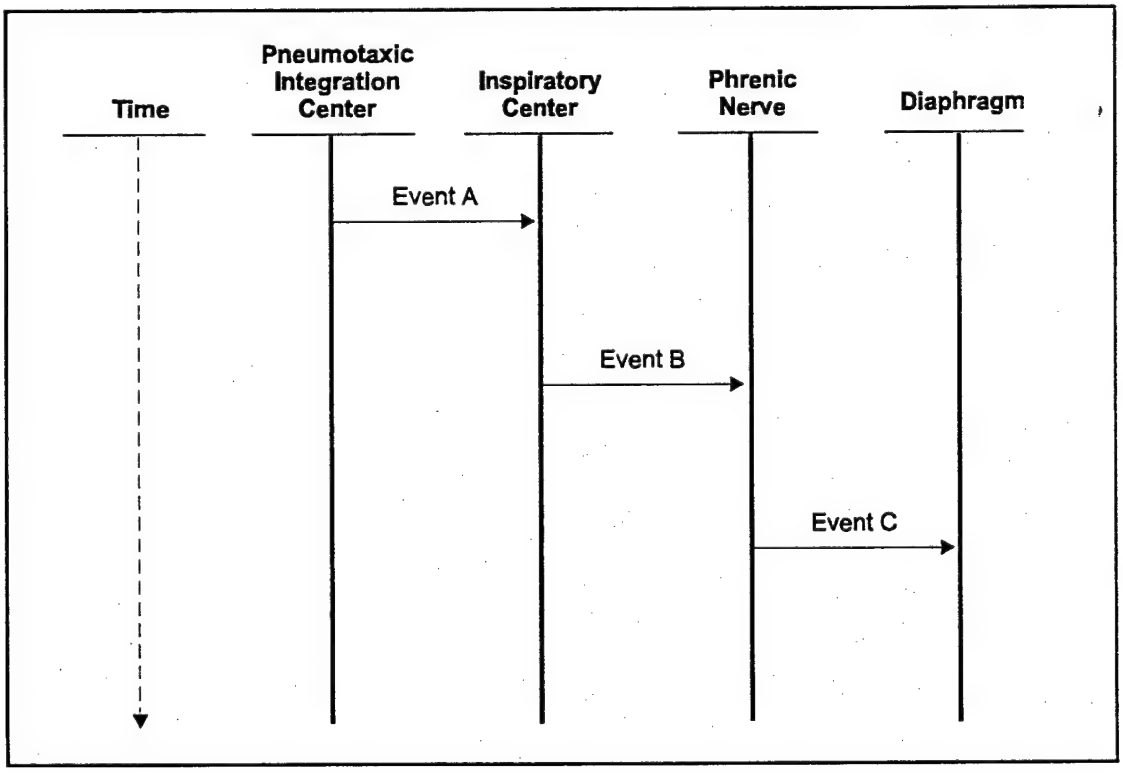

Figure 5. Event Trace Diagram for: "Segment of a Cough Sequence"

In this segment of the "Cough Sequence", the Pneumotaxic Integration Center object, which is one of the subclasses of the respiratory regulatory center objects in the medulla, has already been informed of the presence of an irritant. In Event A, it contacts the Inspiratory Center object with a message to initiate an "inhale". This initiation commences (Event B) with the Inspiratory Center object telling the Phrenic Nerve object to transmit a message. The Phrenic Nerve object sends the Diaphragm object a message to contract.

3.6 Interactions

The interactions which are modeled in the Physiological SOM are actions internal to the body, involving objects that are part of the respiratory or cardiovascular systems or their respective regulatory centers in the medulla. Some of these interactions can occur in response to an external event (stimulus). Many of these interactions are part of the cascade of events starting from the introduction of a stimulus. As such, they involve a modification to the attribute values associated with the physiological objects.

An excerpt of the Interactions structure of the Physiological SOM is given in Table IV.

Table IV. Excerpt of the Interactions List in the Physiological SOM

Interaction Structure		Initiating Object		Receiving Object/Area		Interaction Parameters	Init/ Sense/ React
		Class	Affected Attributes	Class	Affected Attributes		
	TissDistrssc	Lower Limb Tissue	Metabolic Rate	Symp ExtilliacNV	None	pO2ofTissGrp	IR
			pO2 of Tissue Grp			pCO2ofTiss Grp	
			pCO2 Waste			which Problem	
	TissDistressa	UpperLimbTissue	MetabolicRate	SympSubclavianNV	None	pO2ofTissGrp	IR
			pO2ofTissueGrp			whichProblem	
			pCO2Waste			pCO2ofTissGrp	
DecreaseHeartStrok		VagusNV	None	Heart	StrokeVolume	Amount	IR
IncreaseHeartStroke		SympatheticCardiac	None	Heart	StrokeVolume	Amount	IR
HeartRateTrans	ParasymHeartRate	MedullaCardioReg	BPHeartSysMonitor	VagusNV	None	Amount	IR
	IncreaseHeartRate	MedullaCardioReg	BPHeartSysMonitor	SympatheticCardiac	None	Amount	IR
	DecreaseHeartRate	MedullaCardioReg	BPHeartSysMonitor	VagusNV	None	Amount	IR
RelaxTransA		InspiratoryCenter	None	PhrenicNV	None	Amount	IR
RelaxTransB		ExpiratoryCenter	None	AbdominalNV	None	Amount	IR
				IntercostalNV			

ContractTransA		InspiratoryCenter	None	IntercoastalNV	None	Amount	IR
				PhrenicNV			
ContractTransB		Expiratory Center	None	AbdominalNV	None	Amount	IR
				IntercostalNV			
Relax	RelaxAbdominals	AbdominalNV	None	Abdominal	ContractionLevel	Amount	IR
	RelaxInternalInterco	IntercostalNV	None	InternalIntercostals	ContractionLevel	Amount	IR
	RelaxExternalInterco	IntercostalNV	None	ExternalIntercostals	ContractionLevel	Amount	IR
	RelaxDiaphragm	PhrenicNV	None	Diaphragm	ContractionLevel	Amount	IR
Contract	ContractDiaphragm	PhrenicNV	None	Diaphragm	ContractionLevel	Amount	IR
	ContractInternalInter	IntercostalNV	None	InternalIntercostals	ContractionLevel	Amount	IR
	ContractExternalInte	IntercostalNV	None	ExternalIntercostals	ContractionLevel	Amount	IR

The strategy of this section is to discuss the interactions within the context of what event, or set of events, might have caused such interactions to occur. This section forms a bridge between the objects of the Physiological SOM and the scenarios in which the Physiological SOM will participate as one of the federates of the "Human Response" to Stimuli Federation. (See Chapters 5 and 6.) The tactic is to discuss first the interactions which are more limited in scope, and which could occur in a variety of circumstances. This will be followed by a discussion of interactions which occur sequentially, involving numerous objects. It is interesting to note that in the HLA, there is no provision made for bundling a set of interactions which constitute some larger event. For example, the "Cough Sequence", which could occur as a result of particulate irritants in battlefield smoke, does not exist as such within the Object Model Template. Rather, what exists is the list of separate interactions together with any publish/subscribe relationships which must be in place. That is, with regard to the HLA, the "Cough Sequence" is a virtual interaction. Within the OMT, there is no natural way to identify such an interaction.

Proceeding with the discussion of the interactions, consider those interactions which have the term "Trans" as part of the interaction name. Such interactions indicate "transmission" and involve a particular nerve as either the initiating or receiving object. It is noted the nerves serve to carry information from a physiological object to one of the regulatory centers in the medulla, and vice-versa.

The "Tissue Distress" interaction is a base interaction class whose subclasses are distress interactions originating from each of the tissue group objects. The type of distress is indicated through the parameters, which includes excess carbon dioxide or inadequate oxygen levels. The recipient object of these interactions is the appropriate sympathetic nerve (which serves the particular tissue group). In the OMT, such partnership relationships are expressed in the

Associations Table. From a physiological point-of-view, the nerves are merely conductors which relay the information to the appropriate regulatory center in the medulla. In this case, it is the "Medulla Vasomotor Regulator" center which receives the forwarding ("trans") interaction from the specific sympathetic nerve. In response to the situation, this regulatory center initiates interactions which are subclasses of the "Change Artery Diameter Command", and which involve either the constriction or dilation of an artery.

These interactions are the "vasomotor" related interactions. They occur in cases in which the tissue groups are under heavy load, and are not obtaining enough oxygen. This would occur under conditions involving physical exertion. Also, a subset of these interactions would occur in cases of oxygen deprivation, where the brain acts to preserve the blood (oxygen) flow to itself. This would occur in the scenarios involving smoke from fire.

Note that the interactions do not capture all of the activity that would take place in a scenario. The publish/subscribe communications involving attributes of objects are also of great importance.

The activity of the physiological heart as a pump, which moves oxygenated blood through the circulatory system and which has a cardio-pulmonary loop for the re-oxygenation of blood plays a major role in insuring the continued metabolic activity of all body components. This is captured in the Physiological SOM via the "heart" object, together with its attributes. Various situations which require a rapid change in the value of one of these heart object attributes, for example, the heart rate attribute, are captured in the interactions available in the Physiological SOM. Clearly, relevant interactions are those which involve the heart object as the recipient object. This includes "Decrease (or Increase) Heart Stroke Volume", "Decrease (or Increase) Heart Rate", and the associated "trans" interactions involving the cardio-regulatory object and the appropriate nerve (vagus or sympathetic cardiac nerve). The broader picture includes those interactions which support the chain of events leading to the required change in the heart rate attribute values. These interactions are components of events such as "Blood pressure increase to decrease in heart rate" and "Low oxygen levels from the carotid O2 sensor", which were presented in the previous subsection. Note that the start of such events begins with an organic sensor noting a change in the measured quantity. This is done by the appropriate nerve that subscribes to the attribute of the appropriate sensor that contains the measured value. The nerve then conveys the information to the cardio-regulatory center in the medulla which performs algorithmic calculations and responds (issues interactions) accordingly. The interactions which involve the nerves conveying information to the medulla cardio-regulatory center in this context are "Return to Normal pO2", "Low pO2", "Increase BP", "Decrease BP".

These interactions would occur in scenarios involving smoke and gases other than the usual components of air.

Several interactions support the initial reactions of the body to particulate stimuli. Particulates act as irritants. A physiological local response to the presence of an irritant in the bronchia region is the release of histamines which serve to constrict the air passageways. This is supported by a "Constrict Bronchioles" interaction. There is a more complex cascade of reactions caused by the presence of an irritant which results in a cough sequence. These are initiated by the class of "Irritant Sensed" interactions with the recipient object (of the subclasses) the "irritant sensed" interaction being the Pneumotaxic/Integration Center in the medulla. This center is a subclass of the respiratory regulatory center in the medulla. Finally, we allow for the case in which the initial recipient of the stimuli is the class "Body Environ Matrix", by including an interaction from that class to the appropriate irritant sensor.

The remaining interactions of the Physiological SOM support the process of breathing. These remaining interactions can be divided into two main groups. In the first group, the interactions involve the regulatory centers in the medulla that deal with respiration. It is these object classes that host the algorithms governing the physiological breathing control. This group involves interactions such as "start expiratory", "change cycle time", etc. The second group of remaining interactions is concerned with the behavior of the muscles of respiration, and the nerves which communicate the instructions from the regulatory centers in the medulla to these muscles. Interactions belonging to this group include those that are subclasses to "relax" and "contract", and the relax or contract "trans" interactions.

The scenario section of Chapter 5 contains further details on the proper utilization of the interactions.

3.7 Integration

With any complex coupled system, the integration of modes of interaction of the major subsystems becomes crucial. This applies to the cardiovascular and the respiratory systems. Up until now, the focus has been on elucidating the objects and interactions together with the their attributes and parameters. During this exposition, the role of the objects in modeling the anatomical features most relevant to physiological processes and the role of the interactions and publish/subscribe relationships in capturing these processes have been addressed at all but the integration level. The regulatory objects in the medulla have been discussed in terms of their connections to "input" and "output" details (see 3.5 and 3.6), but the overall integration has not yet been addressed.

The "pneumotaxic/integration" center is responsible for providing the integration between the respiratory and cardiovascular systems. The regulatory objects of the cardiovascular system are the cardioregulatory center and the vasomotor regulatory center. The "pneumotaxic/integration" center must listen on the behavior of these cardiovascular centers by utilizing HLA provided

subscription services to the attributes of said centers, in particular the "BPMonitorTissues" and the "BPHeartSysMonitor" attributes. Also, the "pneumotaxic/integration" center receives information due to the irritant sensors via an interaction service. Additionally, this center must be aware of the pH (from chemical sensor) information. This information relay is supported in an interaction structure in which the receiver is the "MedullaReceiveSendCompute" object. Subscription (to interactions), together with inheritance, can deliver this information to the integration center.

The inspiratory and expiratory regulatory centers in the medulla regulate respiratory inspiration and expiration. They originate commands to the muscles of inspiration/expiration transmitted via the nerve conduits. In the case of normal breathing, there is a periodic oscillation set up between these two centers; when one is in a high activity state the other is not. The number of times this cycle of inspiration/expiration occurs per minute yields the respiratory rate. Thus, the respiratory rate is not an ad hoc quantity in this effort, but is a quantity determined by the activity of the modeling for greater physiological fidelity. (The respiratory rate is also a clinical quantity which is understood by the human mannequins. See Chapter 6.)

Physiologically, the "pneumotaxic/integration" center is capable of resetting the operational cycle time between the inspiratory and expiratory centers. This functionality is supported in the modeling by the interaction "ChangeCycleTime", which will affect the attribute "Cycle Time" of the recipient centers. Of course, the decision as to when/how much to effect this change must be implemented, algorithmically, in a manner faithful to the governing physiological principles which requires the information from the cardioregulatory and vasomotor centers.

Chapter 4—Development of the Stimuli Simulation Object Model

4.1 Initial Approach

The point-of-view that was adopted in the development of the Stimuli SOM is that an individual stimulus is a stimulus precisely because it is capable of evoking a reaction in a recipient object. In this project, the object is considered to be the human body with the capabilities and performance of the body specified through the Physiological SOM.

This view-point was fully manifest in the first approach taken in the development of the Stimuli SOM. It is noted that this approach was found to be un-workable and was discarded. In this first approach, the idea of a stimulus being of interest only if the stimulus had an impact upon some physiological component resulted in the requirement that the Stimuli Federate should be able to calculate the first order response of the human body. This means that the Stimuli Federate must know the "state" of the recipient human body. This results in grave scalability issues, which are illustrated in the following example.

4.2 Scalability Issues

Suppose that a stream of "air" consisting only of carbon monoxide is blowing toward the human body. As carbon monoxide will displace oxygen in binding to hemoglobin, breathing of carbon monoxide for a sufficient period of time will prove fatal. So the stimuli "knows" its effect upon the body, it "knows" that it is lethal. However, what if the body is wearing a mask and is breathing a self contained air supply. Then the stimuli is not lethal due to intervening environmental factors. Of course, a Stimuli Federate could request environment information. However, consideration of other possible and reasonable scenarios indicate that the amount of information needed by the Stimuli Federate, in order to calculate the first order effect it will have on the human body, will only grow. For example, what if the mask is cracked. Is it a hairline, or larger crack? What if there is a malfunction in the self-contained air supply? What is the amount of air left in the self-contained breathing unit? It is clear that the Stimuli Federate would have to subscribe to an increasing number of attributes that are involved in specifying a local environment in order to calculate the first order response of the body to the stimuli.

The objection could be raised that the focus of this project should really be on the Stimuli and on the Body Physiology, and should not take any environmental factors into account. This restriction would unduly restrict the scenarios that could be investigated in a "Stimuli-Human Response" Federation. However, even if this onerous restriction were to be adopted, the scalability issue does not disappear.

Consider a human, represented by the Physiological Federate, that is in the process of normal breathing. The Stimuli Federate supplies a stream of carbon monoxide. In order for the Stimuli Federate to calculate the true first order response of the body at that instant in time, it is necessary for the Stimuli Federate to know at what point in the breathing cycle the stimulus is actually received. In order to acquire this information, the Stimuli Federate would have to subscribe to multiple attributes of objects in the Physiological Federate. The Stimuli Federate would find itself in the position of trying to calculate the state of the body but this is precisely the function of the Physiological Federate. Moreover, the meaning of "state of the body" needed in order to for the Stimuli Federate to generate the first order response will vary from stimulus to stimulus.

The end result of this segment of the investigation is to require that the Physiological Federate calculate the state of the body. Of course, the structure of the Physiological Federate is a reflection of what is in the Physiological SOM. To conclude, the first order response of the body is not determined by the Stimuli Federate. A ramification of this is that structure of the Stimuli SOM will not include physiological objects.

4.3 Scalable Approach and Object Identification

The approach to constructing the adopted Stimuli SOM is a scalable one. In the Stimuli SOM, only the classes and subclasses pertain to the stimuli themselves. Of course, the selection of which stimuli to include is open ended.

In keeping with the basic view point that stimuli are that which elicit a response, the human recipient was chosen to be a measure of what stimuli are important. In a very real sense, the Physiological SOM guided the development of the Stimuli SOM. Since the Physiological SOM is focused upon the respiratory and cardiovascular systems, the stimuli of primary interest are those which would affect either of these systems. An additional requirements is the suite of stimuli be of interest to both military and commercial sectors.

The focal point for the stimuli development was selected to include elements which would be present in "battlefield haze" or at the scene of a fire. These include gases, particulate matter, and the potential of toxic vapor clouds. A secondary group of stimuli include certain medical drugs which have specific effects on the respiratory system.

The structure of the Stimuli SOM is largely flat. The depth of the class structure is only one more than the initial base class level. A reprise of the object classes shows the base classes as given in the following Table V.

Table V. Base Class Structure: Stimuli SOM

Air Mixture (PS)	
Smoke Gas Mixture	
Local Particle Cluster Cloud	
Local Chemical Vapor Cloud	
Volatile Chemical Vapor Cloud (PS)	
Gas	subclasses exist
Particle Cluster Cloud (PS)	
Medical Drugs	subclasses exist

Note that only three of the base classes are designated PS (publishable/subscribable). Ordinarily this would not elicit comment as it would be a member of a subclass which would be instantiated and be designated "PS". However, in this case, only two of the base classes have subclasses. Moreover, neither of the members of these subclasses are designated "PS". Also, it appears that some stimuli were listed twice. Consider the case of the "local Chemical Vapor Cloud" and the "Volatile Chemical Vapor Cloud". In the first case, the stimuli is local. It is considered to be in the immediate vicinity of the "virtual human"; essentially co-located spatially with the recipient body. In the second case, the Chemical Vapor cloud is considered to be global; i.e., some distance away from the "virtual human". Note that local stimuli (not designated "PS") which have no global counterpart are those in the subclasses of the "Medical Drugs".

Certain stimuli which are intended to be "global" can be impacted by other environmental factors, such as weather. For example, suppose a volatile chemical vapor cloud having fairly large diameter is created. In the event of a strong wind blowing in a specified direction, the chemical vapor cloud may follow a ground track which adversely affects more humans (virtual humans) than would have been the case without the weather. Alternatively, a storm may serve to disperse the cloud. Terrain features come into play in the movement of a global stimulus. The longevity of a vapor cloud in a valley ringed by mountains on three sides with a temperature inversion occurring is most likely different from the longevity of that same cloud in a plains region. One ancillary area of interest given impetus by this work is that of tying a specific stimulus into a weather generator or an environmental framework. This is discussed further in Chapter 6.

A key requirement is that non-visual stimuli are to be represented, and this representation is to be transmitted within the context of the High Level Architecture. That implies that the recipient of the stimuli must "react" to the stimuli. However, we have taken the scalable approach so that the stimuli will not be calculating part of the recipient's response. It is, therefore, crucial that the

characterization of the stimuli involve sufficient information of the "correct type" so the recipient body can calculate a physiologically correct response and manifest it via a change in the attributes values and perhaps overall state.

One of the limitations of this approach is the lack of any cognitive modeling. No higher brain functions or volitional choices of response are modeled. Thus, only stimuli which reside in the physical domain are properly included in this Stimuli SOM.

It is through the attributes of the stimuli objects that the identity of a particular stimulus is known. The attributes are responsible for conveying the nature of each non-visual stimuli. This is discussed in the following subsection.

4.4 Informational Attributes and Physical Attributes: Convey the Stimulus

Consider the "Volatile Chemical Vapor Cloud" stimulus, which is an object in the Stimuli SOM. It is clear that in order to describe the cloud in relation to some spatial reference point, certain physical parameters must be specified. These include the "diameter" of the cloud, its "altitude" and "location (in lat-long or XY coordinates)", its "speed" and "direction of motion". The "concentration" of the chemical constituting the vapor cloud is a measure of the strength of the cloud. These are all attributes of the object "volatile Chemical Vapor Cloud".

In a similar manner, the physical constituents of the "Smoke Gas Mixture" object, the size (diameter) of the "local Particle Cluster Cloud", etc., are attributes which relate to the physical nature of a stimulus.

Consider the case of the vapor cloud. None of these attributes describes just what the vapor cloud is in relation to the recipient of the stimulus. Would a listing of the chemical formula be sufficient to describe what the cloud is? How would this be useful to a recipient when that recipient is the virtual human? Would the virtual human have enough information to react properly? Alternatively, what information would be required by the virtual human in order to "process" a stimulus?

Again, it is the use of a virtual human as the recipient of the stimuli that shapes the nature of the information that must be carried by a stimulus. The additional attributes which convey the identity of the stimuli vis-a-vis the recipient virtual body are: (1) "Identity Profile", (2) "Potential Level of Injury", (3) "Immediacy of Effect", and (4) "Target System". Great use has been made of the Complex Data Types feature of the OMT as well as the Enumerated Data Types. These four attributes constitute the methodology by which the non-visual stimuli are conveyed to the recipient body.

An excerpt of the Attributes List in the Stimuli SOM which exhibits the Informational Attributes is presented in Table VI.

Table VI. Excerpt of the Attribute List in the Stimuli SOM. The datatype of the attribute is listed in addition to the attribute name.

Object/Interaction	Attribute/Parameter	Datatype
airMixture	perO2	float
	perN2	float
	perCO2	float
	altitude	float
	PotLeveloflnjury	GenericinjuryLevelInfo
	ImmediacyofEffect	ImmediacyofEffectData
	TargetSystem	string
	IdentityProfile	IdentityProfileData
	LocationXY	XYCoorData
localParticleClusterCloud	SizeofParticles	float
	ImmediacyofEffect	ImmediacyofEffectData
	PotLeveloflnjury	GenericInjuryLevelInfo
	IdentityProfile	IdentityProfileData
	TargetSystem	string
localChemicalVaporCloud	Concentration	float
	IdentityProfile	IdentityProfileData
	ImmediacyofEffect	ImmediacyofEffectData
	TargetSystem	string
	PotLeveloflnjury	GenericInjuryLevelInfo

An excerpt of the Complex Data Type List is presented in Table VII.

Table VII. Excerpt of the Complex Data Types table listed in the Stimuli SOM. Only the Field Name and Data Type are given.

Complex Datatype	Field Name	Datatype
ParticleSizeGroupList	SmallSize	boolean
	MediumSize	boolean
	LargeSize	boolean
XYCoorData	X	float
	Y	float
IdentityProfileData	BronchoDila	boolean
	Bronchiocon	boolean
	AveloiInflam	boolean
	ModifyAirPr	boolean
	ModifyAmbi	boolean
	ModifyAmbi	boolean
	BindHEM	boolean
GenericInjuryLevelInfo	Level	InjuryLevelD
	PotentialInjur	

The "Identity Profile" makes use of the complex datatype "Identity Profile Data". The fields are a list of questions to which the stimulus must respond true or false. (The datatype for these fields is Boolean.) These include questions such as "Bronchio Constrictor?", "Bronchio Dilator?", "Aveoli Inflammatory?", "Modify Ambient Air Properties?", "Bind Hemoglobin?", etc. The "Identity Profile Data" contains questions/answers of interest to the virtual patient as it is presently constituted. It is up to the virtual patient to decide how to handle the stimuli. *A cautionary note is in order here.* In specifying the Boolean Set in the "Identity Profile Data" which comprises a particular "Identity Profile", it is important that only one interrogative be marked as TRUE; the interrogative which can be considered to be the primary possible effect that the particular stimulus has on the body.

A failure to heed this cautionary note could result in ambiguities and possible inconsistencies. Which particular interrogative would be associated with the information in the "Potential Level of Injury" information? As it is presently designed, the "Potential Level of Injury Profile" can provide information as to the potential level of injury at various dosages/amounts/concentrations. However, what if a stimulus could result in injury to multiple subsystems, or in multiple ways over

various periods of time? For example, suppose that the presence of particulate matter results in coughing if the particles are of a certain size range. However, let us just suppose that these particles serve to induce cancer if the exposure is at a certain level. Furthermore, suppose that the cancer will not appear for several years. The coughing/choking response and the cancerous growth response cannot both be addressed in the confines of the current complex data structure. It is clear from the context of this effort that we are interested in the immediate response of the coughing. That, for our purposes, is the identity of the particulate matter vis-a-vis the virtual body (patient).

The "Identity Profile" can be expanded in several ways. First, new fields could simply be added to the "Identity Profile Data", containing the new questions. This is a flat extension. This flat extension would be able to serve other stimuli which are *simple*. By a simple stimulus, we mean a stimulus which has one simple identity vis-a-vis the body. Also, we consider a *stimulus* to be simple if it can be considered to have one simple identity vis-a-vis the body *in the conceptual space in which the virtual body is being modeled.*

Alternatively, certain stimuli might evoke multiple direct responses from the body. This is in contrast to a response which starts as single-pointed, although it can cause a cascade of events through the physiological system dependencies. These multiple direct responses could be occurring on different time scales, providing the conceptual space of the modeling was broad enough to encompass these time scales. For example, a time scale of 48 hours might be of interest in a battlefield injury scenario, whereas a time scale of a decade probably would not be of interest from the battlefield medical point-of-view. Such stimuli are termed complex stimuli. To achieve proper representation of these non-visual stimuli, vis-a-vis the human body, will require a more evolved set of complex data structures.

This situation grows more complex if other physiological subsystems are included as part of the virtual patient. For example, if the epidermal system is included as a component system, an additional part of the identity of a vapor cloud, vis-a-vis the human body, might be "caustic". The skin could be burned as a result of this stimuli. This is in addition to the effect of the stimulus on the lungs. Thus, a more complex structure for the "Identity Profile" is required if the virtual patient grows more complex.

Consider further this same stimulus of the particle cloud. Let the recipient be the human body. Reflection on the nature of a particle cloud which envelops the recipient suggests that unprotected eyes will be "hit" by particles. The eyes will then tear. There are no interrogatives in the "Identity Profile" data which deal with watering eyes, although this is clearly one generic part of the identity of the stimulus with respect to the human body. Moreover, if there were such an interrogative, it would have to be presented in the context of a second generation complex data structure representing the "Identity Profile".

This is a push/pull situation which will require the development of a second generation group of Informational Attributes to properly represent and convey the non-visual stimuli. The push proceeds from recognition that certain stimuli are *complex* with respect to their possible effects on even the simplest reasonable representation of the body. The pull will result from a development of the virtual patient to incorporate additional physiological subsystems (at perhaps greater levels of resolution) which interact.

The second of these informational attributes is the "Potential Level of Injury". This attribute bundles information on the *potential* level of injury that is nominally associated with a stimulus. The stimulus does not calculate what actually occurs in the virtual patient. Moreover, the attribute cardinality is "1+", so that multiple potential levels of injury can be communicated. For example, it is known that for a range of dosage exposures to mustard gas, that stimulus is lethal. For a range of different dosages, there is an array of different nominal effects. The datatype for this attribute is a complex data type, the "Generic Injury Level Info". It consists of two fields; the first is "Level" and the second field is "Potential Injury". The datatype of "Potential Injury ", called the "Injury Level Data", is an enumerated datatype, also a special type provided by the OMT.

The third of these informational attributes is the "Immediacy of Effect". Again, this is understood to be nominal information. It is up to the virtual patient recipient to calculate the actual physiological effects. The "Immediacy of Effect" attribute has datatype "Immediacy of Effect Data", which is an enumerated datatype, as provided for in the OMT. Entries in the "Immediacy of Effect Data" include "immediate", " seconds", "few minutes", etc. Additional entries can be easily added.

The final informational attribute requires that the stimulus list a "Target System". This system should be some physiological component. The specificity of "Target System" should depend upon the specificity of the stimulus. Although the effects of the stimulus on the recipient body may cascade through a multitude of interdependent physiological systems, the stimulus is required to specify a primary target. No list of such targets is given. This is done intentionally so as not to predetermine the level of potential interaction. It is up to the virtual patient to determine how information as to the specified target system is utilized. The datatype for this attribute is a string.

For a particular stimulus, the information that is conveyed through these attributes is fixed. With regard to update type in the OMT specification for the attributes, the selection must be "Static". The only situations for which the information profile on a particular stimulus should be modified are (1) more information concerning the stimulus becomes known, and this new information either extends or supersedes previous information, and (2) the resolution of the information given is too coarse, and more detailed information should be conveyed.

This same approach to conveying *pertinent* information about a non-visual stimulus that the recipient of said stimulus will need in order to determine its effect on the recipient can be adopted for cases in which the recipient is not the human physiological system. The key lies in determining the nature of the stimulus vis-a-vis the recipient. The process involves delineating the information that will convey this nature to the recipient in a form that the recipient can utilize in order to calculate effect.

4.4.1 Extended Discussion on Informational Attribute Structure

These informational attributes form a set of attributes, the details of which must be tailored to each new stimulus. Serious questions concerning the efficacy and adequacy of the set of informational attributes arise. Since this structure is the means by which the non-visual stimuli are to be conveyed to the recipient body, any concerns regarding the attributes translate into concern over the ability to represent (and then transmit) the non-visual stimuli.

Consider the question of orthogonality among the informational attributes themselves and with regard to the physical attributes which characterize the stimuli. Orthogonality refers to the independence of the information being addressed by each of the informational attributes and other attributes. Without this independence, a situation could arise in which the specification of two different attributes caused an inconsistency or an error in the representation of the stimulus. Take as an example the "Potential Level of Injury " attribute. The truth of the potential level of injury may depend on the quantity of the stimulus which is present. This potential level of injury may vary from minor, if the amount (or size , dose, concentration, etc.) is "small", to lethal, if the amount is large. Thus, there is a dependency of the "Potential Level of Injury" due to the "amount" of the stimulus that is present. In this case, the situation is remedied by the development of a complex data structure that allows for multiple (unbounded sequence) of "Potential Level of Injury" due to a stimulus, each of which is associated with a level of presence of the stimulus. The hidden dependence is removed at the lowest level by requiring a "coordinate" to describe the potential level of *injuries*, the fields given by the amount of stimuli, and the associated potential level of injury.

No other non-orthogonalities were discerned in this set of attributes, *as long as simple stimuli are considered.*

The basic thesis underlying the approach to representing and transmitting the non-visual stimuli is that of an implicit coupling exiting between the stimuli and the recipient. A discussion of this viewpoint has helped to elucidate the requirements for representing the *simple* stimuli. In summary, discussions with the medical consultant led to the requirement that the physical body demand information as to: (1) how much of the stimulus is present, (2) what is the nominal level

of injury due to the stimulus in the amount present, (3) how fast acting is the stimulus, (4) what are the "features" (identity) of the stimulus vis-a-vis my categories of concern, and (5) what's the primary target system.

Are the stimuli adequately represented for use by the body? Can the body calculate its new state based upon the presence of the stimuli?

The informational attributes and their structure can convey the required information on a *simple* stimulus to the body. However, it is incumbent upon the recipient to embody some level of organization in handling and processing incoming *simple* stimuli. This is reasonable in light of the fact that the very identity profile of the stimuli are cast in the categories that are relevant to the recipient. Let us assume that a future software implementation of the Physiological SOM can calculate its state in the absence of any stimulus. Let us assume that the body is in a normal breathing mode, and that all internal calculations which must be done to advance the state of the body in time are able to be performed. The introduction of a stimulus would affect one or more of the attributes which are needed by the body in the calculation of its internal state. A software implementation of the body must bring in this information, and properly utilize it. Through the framework of the HLA, the information can be brought into the body. The framework for representation of the stimuli was designed so as to allow for the transmittal of *simple* stimulus information in the "right form" that could be used by a "smart body".

At this stage, it is believed that the structure of the Stimuli SOM, subject to its inclusion in a FOM with much input from Physiological SOM , and under the umbrella of a set of selected scenarios, will prove adequate to the task of conveying non-visual *simple* stimuli. It requires an actual implementation to take this question further.

4.4.2 On the Future Informational Attribute Structure: Simple Stimuli versus Complex Stimuli and Extensive Physiological Modeling versus Minimum Systems

At present, the "human body" recipient is a SOM which represents the respiratory and cardiovascular systems in a coupled manner, with the intrinsic ability to simulate respiratory activity, albeit at a certain level of resolution. At present, the Stimuli SOM consists of stimuli which enjoy a "simple" identity relative to the current "human body" SOM. Moreover, there is recognition of the fact that these two different SOM's were developed in the same conceptual space.

Suppose that in the future this is implemented in software and the physiological systems and subsystems which are modeled and implemented increase greatly. There will then be more objects in the Physiological SOM which could be affected by a given stimulus. Of course, some of the objects would be affected indirectly, and in the due course of time due to the coupling between the

components of the body when it is alive and breathing. (This is the current case.) However, it might also be the case that more than one physiological system or subsystem should be considered to be a "target system". In and of itself, this is not a problem. However, orthogonality issues will arise with regard to how long the stimulus takes to have an effect, and with the Identity Profile and its connection to the Potential Level of Injury.

Also, the structure of the Identity Profile must be modified to make sure no inconsistencies in representation of the stimuli vis-a-vis the physiological subsystems arise. The increased complexity of the recipient system feeds back into the representation of the Stimuli and requires a more complex representation of the Stimuli, since this representation is done vis-a-vis the recipient body.

The orthogonality issues arise immediately if the particular stimulus is complex; that is, if it could evoke multiple "primary responses" from the human body.

With regard to development of a second generation of Informational Attributes, one possible approach is to have the "Identity Profile" be the base complex data type. All of the other present informational attributes would represent fields in the "Identity Profile". The present set of interrogatives would be greatly expanded and organized by physiological subsystem. In the case of a complex stimulus, each "primary-type" response would be connected with a "yes" for the correct subset of interrogatives. In the case of a yes answer to interrogatives, other fields would have to be filled in. These other fields would correspond to the remaining Informational attributes of the present effort: these include the "Potential Level of Injury", the "Target System", and the "Immediacy of Effect". Recall that these include complex data structures in their own right.

This structure is capable of being handled under the current HLA OMT rules governing data representation. However, keep in mind that the Identity Profile would be a parameter that has to be passed. It could grow increasingly large.

One intermediate situation is to allow for *complex stimuli*, but to restrict the physiological systems to the present structure. The list of interrogatives would include only those which would have an impact on the cardiovascular-respiratory system, but complex stimuli which enjoy multiple (potential) effects could be communicated. Also, multiple simultaneous simple stimuli could be bundled into one complex stimuli.

If the physiological SOM is to be developed further to include other physiological subsystems, should this be done in a single SOM? Would multiple SOM's allow for smaller Identity Profiles that could still convey the complex stimuli information? If the physiological SOM or set of SOM's is to become more capable of modeling the true complexity of the human body, what would the issues be in terms of data handling? Would data subscriptions be an alternate method?

The needs of the user groups and user requirements will have input into any future development of the stimuli SOM and the physiological SOM.

4.5 Interactions

The interactions represented in the Stimuli SOM are all concerned with the release of stimuli. Consider a particular stimulus that is released. That stimulus is the initiating object. However, there is no recipient object with the context of the Stimuli SOM.

The interactions are listed in a flat structure; no use is made of inheritance. This reflects the rather flat object class structure for the Stimuli SOM, in which limited use is made of inheritance.

What is of most interest in these interactions are the parameters that are sent as part of the interaction. All of the interactions send, as parameters, the four informational attributes: "Identity Profile", "Potential Level of Injury", "Immediacy of Effect", and "Target System". Recall that these informational attributes are composed of complex data structures and enumerated data structures, and are capable of bundling much information.

This is not to suggest that the four informational attributes have the same content for each of the interactions. Quite the opposite situation is the case. The information in each of the four informational attributes is tailored to reflect the character of an individual stimulus for the interaction involving that stimulus.

The interactions listed in the Object Interaction Table of the Stimuli SOM are given in the following table.

Table VIII. Interactions: Stimuli SOM

Administer Methacholine
Administer Albuterol
Smoke Stream Stimulus
Vapor Cloud Stimulus
Monoxide Stimulus
Particle Cloud Stimulus

The first two interactions refer to the administration of medical drugs, with the metacholine and the albuterol being object subclasses of the base class of medical drug. An additional parameter

which must be passed in the interaction specification for both these two stimuli is the dosage. Note that none of the attributes is affected by the interaction.

The first two interactions involve objects which have the potential to cause constriction or dilation of the bronchial passageways in a human respiratory system. They were included as good test interactions for mannequin (human patient simulator) involvement. The remainder of the interactions focus on elements involved in "battlefield smoke" or "fire fighting".

The "Smoke Stream Stimulus" interaction involves the "smoke Gas Mixture" as the initiating object. In addition to the set of informational attributes, the interaction includes, as parameters, those attributes of the object which pertain to the physical nature of the smoke gases: percentage O2, percentage CO, percentage CO2, etc. "duration", which describes the length of time over which the stimulus is acting, is a key parameter in the interaction. None of the attributes of the initiating object are affected by the interaction.

The "Monoxide Stimulus" interaction focuses upon a specific gas as the initiator. Parameters of "amount " and "duration" are required, as well as the set of information attributes. The "amount" parameter is also an attribute of the initiating object.

The "vapor Cloud Stimulus" interaction and the "particle Cloud Stimulus" involve local objects as the initiators. The parameter "duration" is passed in both of these interactions. As in the other interactions, all of the informational attributes are passed as parameters. Moreover, the attributes "concentration" and "size of particles" which are attributes of the respective initiating objects in these two interactions are passed.

The interaction structure which was developed for passing non-visual stimuli to the recipient human body (with specific physiological systems) heavily utilizes parameter passing in order to convey all relevant information. It is interesting to note that in each interaction developed, all of the attributes of the particular initiating object are passed. Of course, the informational attribute set is passed, but the parameter list included all attributes. An additional parameter which was necessary for some of the interactions was the "duration".

Chapter 5—Federation Object Model Development

5.1 Development of Multiple Federation Object Models

The FOM , or Federation Object Model, is that part of the Object Model Template which represents the structure of a Federation, as opposed to a single simulation. (Recall that the Object Model Template is one of the constituents of the High Level Architecture.) We have seen how the capabilities of the body/physiology simulation and the stimuli simulation are reflected in their respective SOM's (Chapters 4, 5). The software implementation of a SOM , which represents a particular simulation, is termed a federate. However, it is the Federation Object Model that reflects the capabilities that present in the "super-simulation" involving the inter-operation of the two federates. The FOM is key to the interoperability between two federates.

The development of the FOM was facilitated through the use of the OMT Tool, which was utilized in the development of both the Physiological SOM and the Stimuli SOM. From a component perspective, the skeleton outlines of the FOM and the SOM are identical. The same list of Tables that must be "filled out" in the construction of a SOM are the same list which must be addressed for a FOM. Upon perusing the contents of a FOM, it might be difficult to determine, at first glance, that the Tables are component pieces of a FOM rather than a SOM.

This is not to say that it would be impossible to deduce that a particular set of Tables represents a SOM rather than a FOM. There are certain features which are allowed in a SOM, but prohibited in a FOM. For example, in a SOM, the publishing and subscription designations are chosen from the set { P, S, PS, N}, where N is neither. In the FOM, the set of choices is { S, PS, N }. While abstract classes (N) are still allowed in a FOM, the possibility of "P's" eliminated; so no attributes will be published without allowing subscription. In the case of interactions, the "I" (initiates) designation is disallowed in FOM's while permitted for SOM's. That is, in a Federation, an interaction that is initiated by an object must be reacted to, or sensed by, some other object in the Federation. For more details, see the *High Level Architecture Object Model Template.*

The Federation Object Model represents the capabilities of a super-simulation that is composed of a number of single simulations "playing together". The capabilities are manifest through the object, attributes, interactions, and parameters. Note that these are all components of a SOM. Indeed, the FOM is composed of contributions from the participant SOM's, although not every component of a SOM is represented in the FOM.

In the current effort, the Simulation Object Models were developed in advance of any implementation. That is, there is no legacy simulation which drove the structure of either the Physiological SOM or the Stimuli SOM. In a sense, this situation complicated the development of

the SOM's due to a richness of possibilities. However, since the development of the Physiological SOM, *in conjunction* with the Stimuli SOM, required attention to the conceptual space in which both the SOM's reside, the resulting FOM construction is facilitated by this common context.

In what is today the more typical case, a FOM would be developed to represent the intended inter-operating of multiple federates which were not developed in conjunction with each other or under the guidance of a reference FOM. This leads to potential semantic and usage conflicts among the objects and attributes of the participating federates. Such conflicts could result in some changes to a federate's SOM. Alternatively, the set of interactions and the level of interplay among the federates might be more limited than would have been the case without the semantic and usage conflicts. (As an aside, we note the high level of interest in reference FOM's on the SISO reflectors. See the URL: http://www.siso.sc.ist.ucf.edu/)

The Federation Object Model (FOM) for this project is intended to represent a "Human Response to Stimuli" Federation. In the efforts of this project, the stimuli simulations are represented in the Stimuli SOM, and the physiological simulations are represented in the Physiological SOM. Technically, the SOM's are disjoint sets. There are no objects in the Stimuli SOM that are found in the Physiological SOM and vice versa. However, it is clear that the SOM's were developed under a common conceptual framework. The Physiological SOM contains objects that could respond to interactions initiated by objects in the Stimuli SOM. Similarly, the attribute of the objects in the Stimuli SOM involve a set of characteristics whose purpose is to identify a particular stimulus to the recipient body. The contents of the FOM should allow for the stimuli to be introduced to the body. These are the interactions which would bridge the two federates. As such, they rightfully belong in a FOM.

We have chosen two representations for the "Human Response to Stimuli" FOM. In the remaining paragraphs of Section 5.1, we discuss the nature of these two representations, certain implementation ramifications, and the question of possible limitations.

FOM Representation Version 1:

In the first representation, the physiological details and capabilities are hidden. The FOM consists of the Stimuli SOM in its entirety. Also included is the "Body Environ Matrix" which is an object in the Physiological SOM. The interactions listed in this first version of the "Human Response to Stimuli" FOM all have as an initiating object one which originates in the Stimuli SOM. The recipient object of each interaction listed in the first version of the FOM is the "Body Environ Matrix" object, which originated in the Physiological SOM. This object acts as the interface between the physiological subsystems and the stimuli.

If this version of the "Human Response to Stimuli" FOM is chosen for implementation, the object "Body Environ Matrix" must be quite sophisticated. From the FOM and SOM tables, it is clear that this object will communicate with other physiological objects through the use of publish/subscribe services. For example, the "lungs" object could subscribe to the "air pressure, humidity, and altitude" attributes of the "Body Environ Matrix" for use in its calculations. The "Lung Respiratory Zone" could subscribe to the "air components" attribute of the "Body Environ Matrix" for use in its gas exchange calculations. However, how would an irritant sensor in the trachea know that a particle has struck it? This communication is done via the "Body Affectors" attribute of the "Body Environ Matrix" object. Note that there can be multiple "Body Affectors"; the cardinality of this attribute was designated 1+. The "Body Environ Matrix" implementation must have enough intelligence to decode the attributes (e.g., "Identity Profile, Target System, Immediacy of Effect, Potential Level of Injury") of the stimuli which are passed as parameters in the interactions. These attributes involve complex data types. The results of the decoding are described as "Body Affectors". In an implementation, a list of strings, expressing situations which could occur as a result of the decoding of the given stimuli, would be constructed.

A possible limitation of this FOM version is that the physiological details are hidden. This version of the FOM has been tailored to the current Stimuli SOM and the current Physiological SOM. Bear in mind that this tailoring of a FOM to reflect the participating SOM's is the methodology which should be followed. However, what if a third federate was interested in joining the "Human Response to Stimuli" federation? Moreover, suppose that this third federate was primarily concerned with modeling the epidermal layer of the human body, and could successfully exhibit the human response to a chemical which affected the cardiovascular-respiratory system. The addition of this new federate to the "Human Response to Stimuli" federation would expand the range of scenarios that could be simulated by the federation. It would be a valuable additional federation member. In order for this new federate to join, however, the Physiological SOM would have to be revisited. Semantics, attributes, and interactions between it and the new Epidermal SOM would have to be investigated, and a totally new FOM developed.

FOM Representation Version 2:

In the second representation of the "Human Response to Stimuli" FOM, the physiological activity is not hidden. The full capability of the body is revealed. This allows for the faster incorporation of a third federate which needs human physiological inputs, or which also models an aspect of human physiology, into the federation.

In this second version of the "Human Response to Stimuli" Federation, the FOM is essentially a union of the two disjoint SOM's (the Stimuli SOM and the Physiological SOM). That is, the FOM is created by putting together the objects, attributes, interactions, and parameters of the Stimuli

SOM and the Physiological SOM. One key feature occurs in the interactions in which a stimulus is the initiating object. In this version of the FOM, no receiving object is specified. It is noted that this is a similar situation to that involving the "Weapon Fire" interaction in the reference FOM (RPR FOM 017). In that interaction, the initiating object is a military entity and there are no designated receiving objects.

With regard to a software implementation, the individual physiological objects would have to decide to which stimuli object attributes and interactions they should subscribe. Recall that the physiological objects present in either the SOM or a FOM should only be present if they represent serious modeling capability. The software representing the physiological objects would then use information obtained by subscription to feed into their internal calculations and/or to update their attributes.

5.2 Scenarios

The following scenarios have been developed as part of the "Human Response to Stimuli" federation. Since the human physiological modeling is limited to the cardiovascular and respiratory systems, the stimuli which are involved in this federation are those which act to evoke a response on these subsystems.

There is some question as to how much detail to present in the scenarios. If the first version of the FOM is considered to provide the operational viewpoint, then the scenario development is very straightforward. With this viewpoint, the physiological cascade of events which flesh out the scenario do not appear, as the physiological details are hidden.

We will consider the second version of the FOM, the one in which the physiological details are in plain view, to govern the operational viewpoint. Moreover, the initial segment of each scenario, in which a particular stimulus is introduced, constitutes the totality of what would be presented if the first FOM version were utilized. This initial segment will be clearly marked.

Scenario 1: Normal Breathing

The first scenario involves "normal" breathing.

Initial Segment:

The stimulus in this scenario is taken to be the airMixture, with the components set to that of normal atmospheric air. The airMixture communicates via the publish/subscribe methodology, rather than by subscription. It is necessary for those (physiological) objects to subscribe to the

relevant attributes of the air mixture. One such physiological object would be "Body Environ Matrix" (in either the first or second versions of the FOM). [End init. seg.]

The human physiological response is given via the participation of the component objects which are represented in the Physiological SOM and in the second version of the FOM. See Chapter 3 for details on the physiological object, interactions, and the integration of activities.

In the execution of the "Human Response to Stimuli" federation, the following sequence of events simulates "normal breathing".

- Inspiratory Center - > Inspiratory Muscles
- Inspiratory Center - > Expiratory Center
- Expiratory Center - > Expiratory Muscles

The inspiratory and expiratory systems operate in a cyclic manner (see section 3.7), with two and three second cycle times, respectively. At the end of the inspiratory cycle, the expiratory cycle is told to turn on. The inspiratory center object implementation assumes a passive state, and listens in to the behavior of the expiratory system so that it will know when to resume a high activity state.

The activation of the inspiratory muscles during inspiration involves signals via the phrenic nerve from the inspiratory center to the diaphragm to contract and, via the intercostal nerve to the external intercostal, to contract. At the end of the cycle, signals are sent for these muscles to relax. In a similar manner, the muscles of expiration, the abdominals, and the internal intercostal, receive signals to contract for expiration. Such signals are sent from the expiratory center via the appropriate nerves. The effect of these contractions and relaxations is to change the thoracic cavity volume, which will allow the lungs to grow or shrink in volume, and result in a change in internal lung pressure which drives the intake/expulsion of gases. Clearly, there must be extensive use made of the subscription services in order for the object models to obtain necessary attribute information in any implementation.

In the implementation of "normal breathing", a stealth viewer should be able to see a regular respiratory rate. Re-oxygenation should be occurring. A stealth monitoring of the pO2, sensors, etc. should be able to determine if this is indeed the case.

Scenario 2: BronchioConstriction

Bronchioles constrict.

Initial Segment:

This scenario may be entered due to the administration of a bronchio-constricting drug, such as the "methacholine" stimulus. This scenario can be initiated using an administer drug interaction listed in both versions of the FOM. The amount of methacholine to be administered can be set by the dosage parameter. The recipient object can be either the Body Environ Matrix (first FOM version) or none (either if second version of the FOM is used). [End init. seg.]

In this scenario, the bronchioles constrict. This leads to reduced air flow in the air passageways. This results in a decreased pO2, and an increased pCO2, as the gas exchange in the lung respiratory zone will not be as efficient.

This situation leads to the following sequence of events.

- The organic chemical sensors see the low pO2.
- The appropriate nerve carries this (signal) information to the medulla. It is the cardio-regulatory center in the medulla which receives the information on low oxygen levels via the vagus and glossopharyngeal nerves.

(The sensors, nerve pathways, and cardio-regulatory center are all object classes within the second FOM which can be instantiated in an implementation.

- The cardio-regulatory center responds appropriately (according to algorithmic constraints).
- As the low pO2 continues, tissue groups will not find their oxygenation needs met. Tissue distress interactions will be sent via sympathetic nerves to the vasomoter center.
- The vasomotor center responds appropriately.

(The tissue groups, associated sympathetic nerves, necessary interactions, and the vasomotor regulatory center which should be present in the implementation are all elements of the second FOM version.)

A stealth viewer can monitor key attributes which indicate the state of the patient.

Scenario 3: Breathing Monoxide Gas

Hemoglobin binding occurs, and a cascade of events result.

Initial Segment:

This scenario may be entered due to the "MonoxideStim" interaction present in both versions of the FOM. This represents the stimulus of carbon monoxide. The recipient object can be either the Body Environ Matrix (first FOM version) or none (either if second version of the FOM is used). The length of time that this stimulus is operative can be set by the duration parameter. [End init. seg.]

The presence of CO replaces hemoglobin in the blood, and thus affects the attribute "Hemoglobin Binding Percent" that is associated with the object Human. Physiologically, this leads to low oxygen transport in the cells.

The same sequence of events which occurred in the previous scenario start the events of this scenario.

However, there is no respite from the lack of oxygen, and the ameliorative effects of the commands from the cardioregulatory center and the vasomotor center do not occur. The pneumotaxic integration center becomes active, and attempts to improve the situation, but still not enough oxygen is carried due to the hemoglobin binding.

Clearly, this scenario involves major attention to threshold levels, and algorithmic details.

Ultimately, this scenario leads to respiratory depression as the medulla can not obtain enough oxygen to sustain its activity.

Scenario 4: Particulate Irritant Stimulus

Irritant sensor cells become cognizant of the irritant, and a cascade of events occurs.

Initial Segment:

This scenario may be entered in one of two ways. The first involves the "local Particle Cluster Cloud" interaction, which is present in both versions of the FOM. The second method of introducing this stimulus involves the "Global Particle Cluster Cloud", which is publishing its attributes. The "Human Response to Stimuli" Federation may subscribe to such attributes on behalf of the Body (or Patient) federate. The recipient object of the stimulus (if the interaction introduces the stimulus) is the "Body Environ Matrix" if the first version of the FOM is used, and could be implemented in the same way if the second version of the FOM is used. [End init. seg.]

Again, this sequence of physiological activities is listed in the scenario only if the second version of the FOM is the operative viewpoint. There are two primary responses to the irritant. The first response leads to the bronchio-constriction that was discussed in a preceding scenario. That will not be repeated.

The second scenario involves a "Cough Sequence", which will be listed here, as it is somewhat involved. The scenario sequence proceeds as:

- Interaction "Irritant Sensed" alerts "pneumotaxic/integration center"
- This center shortens the inspiratory period; makes expiratory end if operative; the expiratory center relaxes abdominal muscles (via nerve pathways).
- This center shortens the inspiratory period, and forces it to act.
- Quick inspiration—the inspiratory center contracts the diaphragm (via phrenic nerve).
- The epiglottis closes, the lung inflates.
- Lung pressure builds.
- The pneumotaxic/integration center sees maximum inflation, shuts off inspiratory (diaphragm relaxes), forces expiratory (contracts abdominals).
- Epiglottis opens, cough occurs.

Chapter 6—Extensions and Applications

6.1 Mannequin Identification and Interfacing Considerations

Two medical mannequins which simulate certain aspects of the human patient were identified. The first of these medical mannequins is available from Eagle Simulation, Inc., and is termed the "Eagle Patient Simulator". The "patient" is computer controlled in real-time. In addition to an operator's console, there is a "bedside" hand-held controller. However, the "patient" mannequin is not hardware alone. Various software "Physiologic Models" are involved in its functioning. These include: cardiovascular models, lung models, temperature models, fluid models, and drug models. The Eagle Simulation patient is capable of exhibiting a variety of cardiovascular and respiratory events.

The second mannequin identified is the "Human Patient Simulator" offered by M.E.T.I. (Medical Education Technologies, Inc.). It has the capabilities described by the first mannequin. Both of the mannequins are utilized in medical education, primarily in anesthesia departments at medical colleges. From viewing the web connections, it appears that both of the mannequins enjoy good representation in medical schools. Both of the mannequins focus upon using clinical quantities (in addition to any required physiological quantities). The M.E.T.I. mannequin has the added capability of receiving input from clinical monitors.

With regard to the interfacing issues, both mannequins are proprietary. Moreover, in a discussion with a technical representative of M.E.T.I., it is clear that the company regards its product as not only the hardware of the Human Patient Simulator (HPS) product, but also physiological software. The company's interest in physiological software as a product may extend beyond the immediate needs of enhancing/improving the capabilities of the mannequin.

The hardware interfacing issues have been addressed in work that was recently reported upon at the Spring 1998 Simulation Interoperability Workshop. The project of a "Combat Trauma Patient Simulator" (CTPS) [see Pettitt et al, 1998] involved a consortium of companies, including M.E.T.I., brought together for the purpose of developing the dual purpose training and analysis, focused upon reducing combat casualties. The injury is generated using an electronic combat casualty generator (ECC), and the combatant is represented by the Human Patient Simulator. HLA provides the architecture through which the disparate components communicate. Individual RTI Interfaces were developed for the ECC and the HPS. Moreover, a "Patient Simulator" was developed to hold the physiological state of the patient. The CTPS project has, as one of its future goals, the task of improving the Patient Simulator.

The CTPS project has addressed successfully several of the interface issues that occur in the integration of the mannequin into an HLA simulation. Any future work involving the implementation of the "Human Response to Stimuli" federation would seek to use the CTPS knowledge as a baseline from which to proceed.

6.2 Reference FOM, Physiological Modeling, and Educational Applications

One of the original goals of this SBIR project was that of interfacing the virtual patient with the Human Patient mannequin hardware via HLA. If that goal is the sole driver, then the conceptual space of the virtual patient is mapped to the capabilities of the medical mannequin. This serves to organize and delimit the Physiological SOM.

The medical mannequin itself can be viewed as a hardware simulation driven by both direct inputs and software commands. There are physiological models in the software which are an integral part of the medical mannequin. Thus, the medical mannequin can be viewed as a validated simulation (in hardware). It is therefore not unreasonable to let the physiological capabilities of the medical mannequin serve as a basis from which to design the first Physiological SOM. It is noted that such capabilities center around the respiratory and cardiovascular systems.

The version of the Physiological SOM that has been developed for this project does indeed focus on the respiratory and cardiovascular systems.

In looking towards potential uses of distributed simulation involving the human body, we see training and education as prime application areas. One of the goals of the Combat Trauma Patient Simulator is to reduce battlefield casualties through enhanced training with the medical mannequin as a simulated casualty. With regard to educational applications, it is clear that any simulations must be high fidelity. For example, the "Human Patient Simulator" (from M.E.T.I.) is used to train anesthesiologists. This requires fidelity in the area of drug reactions.

The educational simulations involving human physiological systems do not necessarily require a hardware mannequin in the loop. Consider a situation in which medical students access, and interact with, a "virtual human" or "virtual patient" which is provided from a server on campus. With the trend in medical education involving externships away from campus and in a more clinical setting, distributed simulations serve as a valuable educational aid.

Alternatively, consider a situation in which there is one "Human Patient Simulator" in the loop, and a number of "virtual patients", one for each anesthesiologist in training. The "Human Patient Simulator" could provide "ground truth". Each medical specialist student would be able to run

simulations on his/her own "virtual patient", and see the effects of their efforts manifested on the mannequin.

What role could HLA play in the development of the aforementioned simulation capabilities? We note that in the present Stimuli SOM, one of the object classes is that of "medical drugs". At present, both a bronchio-constrictor and a bronchio-dilator are represented. A future evolution of the Stimuli SOM could be a suite of anesthesia drugs.

There is recognition of the fact that any medical modeling and simulation must involve fidelity to the actual physiological systems. A recent on-line paper [DeCarlo et al] provided by the Center for Human Modeling and Simulation and the TraumaAID Project at the University of Pennsylvania addresses this question. Their approach is to use engineering mechanics techniques to model certain physiological subsystems, including the lungs. We found a mechanical engineering viewpoint to be helpful in the development of the object classes. Moreover, we adopted the functional physiological viewpoint for development of the Physiological SOM, as contrasted to an anatomical approach.

How can the structure of the HLA be used to insure fidelity in the modeling and simulation of human physiological behavior when subjected to trauma or interacting with medical drugs (both of which are stimuli of a sort)? A reference Physiological FOM would aid in this effort. (It is noted that several of the more typical areas of DoD interest, such as sensors and C4I, are considering the development of a reference FOM for their respective areas. See the reflectors at SISO for details of the ongoing discussions.)

6.3 Distributed Simulation Considerations

Latency

Several issues arise in the implementation of distributed simulations which are interactive. The interaction between the simulations results from the communication necessary to convey information that is held by one federate, but needed by another. The distribution of the simulation can be over several machines networked in the same room, a local network, a network which spans thousands of kilometers, or the Internet. Networking could be done by Ethernet (or ATM), or the networking may be specialized, as in the case of a network of high performance workstations. Latency inherent in the nature of such distributed simulation may affect the integrity of the simulation.

Latency arises from both hardware and software sources. In the discussion of network latencies given in Patterson and Hennessey [1998], there is a hardware latency to/from the network as well

as what is termed an interconnect latency that could include time for the information to "come over the wire" (important in long networks). Also, the extra time needed by the HLA infrastructure can be viewed as a latency, even though it is an enabling software technology for distributed interactive simulations.

For purposes of discussion, let us assume that only one federate is hosted on each machine. Moreover, the run time infrastructure (RTI) of the HLA will be assumed to be hosted on a separate machine. Recall that the interactions and the subscribe/publish information can only be passed through the RTI. So, in the case of the "Human Response to Stimuli" federate, there are three machines which are hooked together. There is no requirement that the machines be in the same room, on the same local area network, or even in the same geographical area. Let us assume that the Physiological federate and the RTIExec are hosted on two machines that are on a local area network on a university campus, and that the Stimuli Federate is running on a machine that is geographically located hundreds of miles away. Furthermore, let us assume that a mannequin is introduced into the simulation to provide "ground truth". This mannequin functions as hardware in the loop. Let the mannequin be interfaced into the federation such that it will mirror the conditions in the Physiological federate. Moreover, let the mannequin be hosted at a satellite campus that is equidistant from the two federates. Information from the stimuli federate will affect the physiological federate. At what rate can this be mirrored in the mannequin status? What are the data buffering requirements, if any? If the Internet provides the connectivity, how is the integrity of the simulation affected?

Distributed Simulation and the HLA

Simulation in general and distributed simulation in particular have been fields of endeavor prior to HLA. See, for example, the recent text by Hamilton et al [1997] which gives an overview of the various facets of distributed simulation.

The arrival of the Internet has generated a new sub-area in the simulation field; that of distributed simulation over the world wide web. There are simulation tools which have been developed specifically for this "platform", e.g., SILK (See the References, Healy and Kilgore). A recent paper by Page et al [1997] looks at simulation over the web using SIMJAVA with remote method invocation.

The status of HLA vis-a-vis distributed simulation over the Internet is an open question. Additional work of Page et al [1998] is looking at approaches for "incorporating discrete event simulation conceptual frameworks within the HLA".

It is noted that educational activity is thought to be one of the premier uses of distributed simulation over the web. An educational simulation could well be very "content-heavy", such as is the case with the physiological system modeling. Within the context of the HLA, the content is introduced through the Object Model Template component of the HLA. In the present effort, the work of the Physiological SOM is an example of the "content-heavy" SOM.

6.4 Relation of Weather, Stimuli, and the "Virtual Human"

One can envision training scenarios involving the "virtual human" and stimuli in a hostile setting. The "virtual human" can be viewed as a "virtual combatant". Consider the case in which the stimulus is the (global) chemical vapor cloud. Training scenarios can revolve around the use and proper maintenance of protective equipment. In this case, each trainee would be issued a personal "virtual combatant" which could provide "ground truth" as to whether the combatant was able to avoid the effects of the chemical cloud. After the combatant is protected, he/she could interact with the "virtual combatant" by sending a completion message. The physiological state of the "virtual combatant" could then be assessed, providing feedback. This would be another use of the "Human Response to Stimuli" federation.

Weather and terrain both affect the concentration and location of the chemical vapor cloud. Both weather and terrain are large scale environmental features that have great impact on the war fighting scenarios. A recent SIW paper by Whitney et al [1998] discusses the experiences from the STOW 97 exercise from the view-point of environmental effects on war-fighter training.

Integration of weather and terrain effects predate the development of the HLA; with weather servers having been developed in support of distributed interactive simulations. See the brief on-line overview of the WIND's effort [Smith et al, TASC, web-site in references]. With the advent of HLA came the news to reconsider environmental effects in a new context. The online FAQ manuscript [Hummel, ANL, web-site in references] by Hummel addresses aspects of inserting environmental effects in DMSO's HLA. A more global view is taken as weather is now a part of the total environmental picture. In the FAQ, " if a federation has environmental interactions that cross federation boundaries and/or if the simulation involves activities that can cause changes to the environment (i.e., dynamic environmental feedback), then the environment *must be* represented as objects and interactions at the FOM level."

The vapor cloud stimulus can certainly be affected by strong winds. Since the environment, including weather, must be represented in the context of HLA, and include objects and/or interactions, the envisioned "Human Response to Stimuli" Federation could be extended to include an environmental or weather federate.

Recent developments in incorporating the natural environment into federations under the HLA/RTI paradigm include the TAOS effort [Whitney et al, 1997] and the DEEM effort [Hummel et al, on-line manuscript, 1998, anl site in references]. The DEEM effort is the "Dynamic Environmental Effects Model", which was originally developed at Argonne National Laboratory as part of a U.S. Department of Energy effort to model and visualize the effects of environmental remediation. This model was part of the Joint Training Federation Prototype (JTFp). Its object classification scheme had certain real world atmospheric, land, and water objects. What it did *not* consider as part of the Joint Training Federation prototype team was possible atmospheric objects such as "plume transport from smoke surfaces". Such atmospheric objects like air pollution plumes are similar in nature to chemical vapor clouds. The entity resides in the atmosphere, is subject to geophysical fluid dynamic forces, yet is not naturally occurring. It might be the case that this is available in DEEM, but was not implemented in the prototype.

The TAOS, or Total Atmosphere Oceans System, is "being developed ... to provide tactically significant, high-fidelity atmosphere-ocean-surf environments to distributed simulations using HLA/RTI" [Whitney et al, 1997]. TAOS provides spatial and temporal data from the ocean, atmosphere, and surf zones, in gridded form. The spatial data is three-dimensional. Also, linkages are provided between the simulation and the data source. It does not appear that TAOS is "running" weather forecasting models to provide this data, but it appears that it would provide a linkage to the weather data that was generated by such a source. TAOS will provide linkages to gridded forecast products (to be) resident in the Master Environmental Library (MEL) of DMSO [Whitney et al, 1998]. However, what is most interesting about TAOS from the view-point of the stimuli is the "embedded features" aspect. The environment (atmosphere-ocean-surf zone) is defined to have a base state which represents the more global general state. Any fine-scale or localized feature is to be represented as an "embedded" feature. The example of an embedded feature which is given in Whitney et al [1998] is that of a localized dust storm.

It appears that what we consider as *simple global stimuli* in the Stimuli SOM can be viewed as embedded features within the framework of TAOS. Of course, while the attributes of the stimuli in the Stimuli SOM include those which convey an identity vis-a-vis the human body, such a representation is foreign to TAOS. Nonetheless, it seems reasonable to envision that the TAOS system would work naturally in conjunction with the "Human Response to Stimuli" federation.

It is noted that the situation is in flux with regard to synthetic environments and environmental modeling. The creation of "SEDRIS" [See URL address in reference list.] as an "open transmittal medium" will have an impact on how any stimulus should/could be incorporated into or linked to an environment model. SEDRIS will provide a standardized Data Model as well as programmer API's. Part of the power of SEDRIS derives from the fact that the conceptual space from which it originated considered not only environmental concerns and models, but also the parameters

relevant to the warfighter. Insofar as a stimulus from the Stimuli SOM can be embedded in an environmental model, it will also be subject to handling via the SEDRIS methodology. Even if the Stimuli federate (as defined by the Stimuli SOM) is not considered to be part of any environmental model, but rather is considered to be a contributor to a synthetic environment, it will fall into the domain of information covered by SEDRIS in the future. Thus, any future implementations which involve the Stimuli federate (Stimuli SOM) in a broader context than just the "Human Response to Stimuli" federation with strictly local stimuli needs to consider the interface issues with SEDRIS.

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Appendix A

Class1	Class2	Class3
OrganicDuctwork	NervousDuctwork	SympAbdomViscNV (PS)
		SympEsophgNV (PS)
		SympCarotidNV (PS)
		SympSubclavianNV (PS)
		SympIntIlliacNV (PS)
		SympExtIlliacNV (PS)
		SympRenalNV (PS)
		SympBronchialNV (PS)
		SympatheticCardiacNerve (PS
		AbdominalNV (PS)
		IntercostalNV (PS)
		GlossopharyngealNV (PS)
		PhrenicNV (PS)
		VagusNV (PS)
		SpinalColumn (PS)
	RespiratoryDuctwork	Pharynx (PS)
		Larynx (PS)
		Trachea (PS)
		Bronchia (PS)
	CardiovascularDuctwork	ArteryinBody
		Aorta

Class4
ExternalIlliacArtR (PS)
ExternalIlliacArtL (PS)
InternalIliacArtR (PS)
InternalIliacArtL (PS)
IliacArtR (PS)
IliacArtL (PS)
AbdomParietArtL (PS)
AbdomParietArtR (PS)
AbdomViscArtL (PS)
AbdomViscArtR (PS)
RenalArt (PS)
EsophagealArt (PS)
IntercostalArt (PS)
BronchialArt (PS)
SuperiorPhrenicArt (PS)
SubclavianArtL (PS)
CommonCarotidArtL (PS)
SubclavianArtR (PS)
CommonCarotidArtR (PS)
BrachiocephalicArt (PS)
CoronaryArteryR (PS)
CoronaryArteryL (PS)
PulmonaryArteryR (PS)
PulmonaryArteryL (PS)
PulmonaryTrunk (PS)
DescendingAorta (PS)
AscendingAorta (PS)
AorticArch (PS)

Class1	Class2	Class3
		VeininBody
Organs	Heart (PS)	
	Lungs (PS)	
OrganicRCPTRS	ChemoReceptor	CO2Sensor
		PHSensor
		O2Sensor
	BaroReceptor	BAROAorticArch (PS)
		BAROCarotidSinus (PS)
	IrritantSensor	AveolarIrritantSensor (PS)
		BronchioleIrritantSensor (PS)
		LarynxIrritantSensor (PS)
		TrachealIrritantSensor (PS)
TissueGroups	UpperLimbTissue (PS)	
	HeadNeckSpineTissue (PS)	
	LowerLimbTissue (PS)	
	IntIlliacViscNParietTissue (PS)	
	AbdomViscera Tissue (PS)	
	KidneyTissue (PS)	
	HeartTissue (PS)	
	EsophagusTissue (PS)	
	LungTissue (PS)	
	RespiratoryMuscles	Abdominal (PS)
		ExternalIntercostals (PS)
		InternalIntercostals (PS)
		Diaphragm (PS)
Cavities	NasalCavity (PS)	
	ThoracicCavity (PS)	

Class4
InternalIliacVeinR (PS)
InternalIliacVeinL (PS)
ExternalIliacVeinR (PS)
ExternalIliacVeinL (PS)
SuperiorVenaCava (PS)
InferiorVenaCava (PS)
RenalVein (PS)
PhrenicVein (PS)
HepaticPortalVein (PS)
AzygosVein (PS)
BrachiocephalicVeinR (PS)
BrachiocephalicVeinL (PS)
SubclavianVeinR (PS)
SubclavianVeinL (PS)
JugularVeinsR (PS)
JugularVeinsL (PS)
PulmonaryVeinsR (PS)
PulmonaryVeinsL (PS)
CoronaryVeinR (PS)
CoronaryVeinL (PS)
MedulCO2Recpt (PS)
MedulPHRecpt (PS)
CarotO2Recpt (PS)
AorticO2Recpt (PS)

Class1	Class2	Class3
	PleuralCavity (PS)	
Chambers	HeartChambers	VentricleLeft (PS)
		VentricleRight (PS)
		AtriaLeft (PS)
		AtriaRight (PS)
Valves	HeartValves	AorticSemiLunarValve (PS)
		PulmonarySemiLunarValve (P
		MitralValve (PS)
		TricuspidValve (PS)
Epiglottis (PS)		
LumpedZones	LungConductingZone (PS)	
	LungRespiratoryZone (PS)	
Human (PS)		
CardiovascularSystem (S)		
RespiratorySystem (S)		
BodyEnvironMatrix (PS)		
MedullRecvSendCompute (S)	MedullaRegulatoryCenter	MedullaVasomotorReg (PS)
		MedullaCardioReg (PS)
		MedullaRespirReg
Manager	**Federate**	
	Federation	

Class4
InspiratoryCenter (PS)
ExpiratoryCenter (PS)
Pneumotaxic/IntegrationCenter

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
StartExpiratory		InspiratoryCenter	activityState	ExpiratoryCenter
			status	
CeaseInhale		Epiglottis	status	InspiratoryCenter
InflationMaximum		Lungs	LungVolume	Pneumotaxic/Integra
ChangeCycleTime		Pneumotaxic/IntegrationCenter	activityState	ExpiratoryCenter
			status	InspiratoryCenter
OpenEpiglottis		Pneumotaxic/IntegrationCenter	activityState	Epiglottis
			status	
		ExpiratoryCenter	CycleTime	
			activityState	
			status	
CloseEpiglottis		Pneumotaxic/IntegrationCenter	activityState	Epiglottis
			status	
ConstrictBronchioles		BronchioleIrritantSen	None	Bronchia
IrritantSensed	AveolarIrritantSense	AveolarIrritantSenso	None	Pneumotaxic/Integra
	BronchioleIrritantSen	BronchioleIrritantSen	None	Pneumotaxic/Integra
	LarynxIrritantSensed	LarynxIrritantSensor	None	Pneumotaxic/Integra
	TracheaIrritantSens	TracheaIrritantSens	None	Pneumotaxic/Integra
IrrSensorActivated	TracActIS	BodyEnvironMatrix	None	TracheaIrritantSensor
	LaryActIS	BodyEnvironMatrix	None	LarynxIrritantSensor
	BronActIS	BodyEnvironMatrix	None	BronchioleIrritantSensor
	AvelActIS	BodyEnvironMatrix	None	AveolarIrritantSensor
ChangeArteryDiameterCommand	DilateArtery	MedullaVasomotorReg	BPMonitorTissues	AbdomParietArtL
				AbdomParietArtR
				AbdomViscArtL
				AbdomViscArtR
				RenalArt
				CommonCarotidArtL
				IlliacArtL
				BronchialArt
				EsophagealArt
				ExternalIlliacArtL
				SuperiorPhrenicArt
				BrachiocephalicArt
				CommonCarotidArtR
				ExternalIlliacArtR
				CoronaryArteryL
				CoronaryArteryR
				IntercostalArt
				SubclavianArtR
				SubclavianArtL

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
status activityState	None	IR
activityState	None	IR
None	None	IR
CycleTime CycleTime	Direction CycleChange	IR
status	None	IR
status	None	IR
Diameter	Amount	IR
None	Location	IR
None	Location	IR
None	Location	IR
None	Location	IR
Status	TurnOn LevelofIrritant	IR
Status	TurnOn LevelofIrritant	IR
Status	TurnOn LevelofIrritant	IR
Status	TurnOn LevelofIrritant	IR
Diameter	Amount	IR

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
				PulmonaryArteryL
				PulmonaryArteryR
				IlliacArtR
				InternalIlliacArtL
				InternalIlliacArtR
	ConstrictArtery	MedullaVasomotorReg	BPMonitorTissues	AbdomParietArtR
				AbdomParietArtL
				AbdomViscArtL
				AbdomViscArtR
				BrachiocephalicArt
				BronchialArt
				CommonCarotidArtL
				CommonCarotidArtR
				CoronaryArteryL
				CoronaryArteryR
				EsophagealArt
				ExternalIlliacArtL
				ExternalIlliacArtR
				IlliacArtL
				IlliacArtR
				IntercostalArt
				PulmonaryArteryL
				PulmonaryArteryR
				RenalArt
				SuperiorPhrenicArt
				SubclavianArtR
				SubclavianArtL
				InternalIlliacArtL
				InternalIlliacArtR
TissDistressTrans		SympAbdomViscNV	None	MedullaVasomotorReg
		SympExtIlliacNV		
		SympSubclavianNV		
		SympEsophgNV		
		SympIntIlliacNV		
		SympCarotidNV		
		SympBronchialNV		
		SympRenalNV		
TissueDistress	TissDistressh	LungTissue	MetabolicRate	SympBronchialNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressg	EsophagusTissue	MetabolicRate	SympEsophgNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressf	KidneyTissue	MetabolicRate	SympRenalNV
			pO2ofTissueGrp	

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
Diameter Diameter	Amount	IR
None	pO2TissGrp Location pCO2TissGrp whichProb	IR
None	pO2ofTissGrp pCO2ofTissGrp whichProblem	IR
None	pO2ofTissGrp whichProblem pCO2ofTissGrp	IR
None	pO2ofTissGrp pCO2ofTissGrp	IR

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
			pCO2Waste	
	TissDistresse	AbdomViscera Tissue	MetabolicRate	SympAbdomViscNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressd	IntIlliacViscNParietTissue	MetabolicRate	SympIntIlliacNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressc	LowerLimbTissue	MetabolicRate	SympExtIlliacNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressb	HeadNeckSpineTissue	pO2ofTissueGrp	SympCarotidNV
			MetabolicRate	
			pCO2Waste	
	TissDistressa	UpperLimbTissue	MetabolicRate	SympSubclavianNV
			pO2ofTissueGrp	
			pCO2Waste	
DecreaseHeartStrok		VagusNV	None	Heart
IncreaseHeartStroke		SympatheticCardiac	None	Heart
HStrokeVolumeDecr		MedullaCardioReg	BPHeartSysMonitor	VagusNV
HStrokeVolumeIncrT		MedullaCardioReg	BPHeartSysMonitor	SympatheticCardiac
HeartRateCommand	ParasymIncreaseRa	VagusNV	None	Heart
	IncreaseRate	SympatheticCardiac	None	Heart
	DecreaseRate	VagusNV	None	Heart
HeartRateTrans	ParasymHeartRatel	MedullaCardioReg	BPHeartSysMonitor	VagusNV
	IncreaseHeartRate	MedullaCardioReg	BPHeartSysMonitor	SympatheticCardiac
	DecreaseHeartRate	MedullaCardioReg	BPHeartSysMonitor	VagusNV
ChemPHParasymTrans		MedullRecvSendCompute	None	VagusNV
ChemPHSympTrans		MedullRecvSendCompute	None	SympatheticCardiac Nerve
RelaxTransA		InspiratoryCenter	None	PhrenicNV
				IntercostalNV
RelaxTransB		ExpiratoryCenter	None	AbdominalNV
				IntercostalNV
ContractTransA		InspiratoryCenter	None	IntercostalNV
				PhrenicNV
ContractTransB		ExpiratoryCenter	None	AbdominalNV
				IntercostalNV
Relax	RelaxAbdominals	AbdominalNV	None	Abdominal
	RelaxInternalInterco	IntercostalNV	None	InternalIntercostals
	RelaxExternalInterco	IntercostalNV	None	ExternalIntercostals
	RelaxDiaphragm	PhrenicNV	None	Diaphragm
Contract	ContractDiaphragm	PhrenicNV	None	Diaphragm
	ContractInternalInter	IntercostalNV	None	InternalIntercostals
	ContractExternalInte	IntercostalNV	None	ExternalIntercostals

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
	whichProblem	
None	pO2ofTissGrp	IR
	pCO2ofTissGrp	
	whichProblem	
None	pO2ofTissGrp	IR
	pCO2ofTissGrp	
	whichProblem	
None	pO2ofTissGrp	IR
	pCO2ofTissGrp	
	whichProblem	
None	pO2ofTissGrp	IR
	pCO2ofTissGrp	
	whichProblem	
None	pO2ofTissGrp	IR
	whichProblem	
	pCO2ofTissGrp	
StrokeVolume	Amount	IR
StrokeVolume	Amount	IR
None	Amount	IR
None	Amount	IR
HeartRate	Amount	IR
HeartRate	Amount	IR
HeartRate	Amount	IR
None	Amount	IR
None	Amount	IR
None	Amount	IR
None	DecreaseInSV	IR
	DecreaseInHR	
None	IncreaseInHR	IR
	IncreaseInSV	
None	Amount	IR
None	Amount	IR
None	Amount	IR
None	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
	ContractAbdominals	AbdominalNV	None	Abdominal
ReturnToNormalpO2		VagusNV GlossopharyngealN	None	MedullaCardioReg
LowpO2		VagusNV GlossopharyngealN	None	MedullaCardioReg
IncreaseBP		GlossopharyngealN VagusNV	None	MedullaCardioReg
DecreaseBP		VagusNV GlossopharyngealN	None	MedullaCardioReg
Manager.Federate	**Alert**	**Federate**	**None**	**Federate**
	ObjectInformation	**Federate**	**None**	**Federate**
	PublishingClass	**Federate**	**None**	**Federate**
	SubscribingClass	**Federate**	**None**	**Federate**
Manager.Federate.ServiceLog	**ServiceLogArguments**	**Federate**	**None**	**Federate**
Manager.Federate.Action	**RequestPublicatio**	**Federate**	**None**	**Federate**
	RequestSubscripti	**Federate**	**None**	**Federate**
	SetTiming	**Federate**	**None**	**Federate**
	RequestObjectInfor	**Federate**	**None**	**Federate**
	ModifyAttributeState	**Federate**	**None**	**Federate**
	Control	**Federate**	**None**	**Federate**
Manager.Federate.Action.RemoteServiceInvocation	**DoResignFederatio**	**Federate**	**None**	**Federate**
	DoDeleteObject	**Federate**	**None**	**Federate**

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
ContractionLevel	Amount	IR
BPHeartSysMonitor	pO2Value	IR
BPHeartSysMonitor	pO2Value	IR
BPHeartSysMonitor	Amount	IR
	Location	
BPHeartSysMonitor	Amount	IR
	Location	
None	AlertSeverity	IR
	AlertText	
	AlertID	
None	ObjectID	IR
	LockedAttributes	
	RegisteredClass	
	RepresentedClass	
None	ObjectClass	IR
	InteractionClass	
None	ObjectClass	IR
	InteractionClass	
None	Handle1	IR
	Handle2	
	HandleSet	
	ObjectIDorCount	
	TagOrLabelOrNam	
	Time	
	Enumeration	
	Boolean	
None	None	IR
None	None	IR
None	FedReportPeriod	IR
	TimeReportPeriod	
	ObjectReportPerio	
None	ObjectID	IR
None	ObjectID	IR
	AttributeID	
	TokenState	
None	SetServiceLogging	IR
	SetLogFile	
	DeleteObject	
	DequeueFIFO	
None	ResignAction	IR
None	ObjectID	IR
	Time	
	Tag	

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
	DoSetLookahead	Federate	None	Federate
	DoSetTimeConstra	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
None	Lookahead	IR
None	State	IR
None	None	IR
None	None	IR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
NervousDuctwork	TransmissionFactor	double	1
Heart	HeartRate	double	1
	StrokeVolume	double	1
	CardiacOutput	double	1
	PeripheralResistanceTotal	double	1
	ForceOfContraction	double	1
	BloodPressure	double	1
Lungs	LungVolume	double	1
	InternalLungPressure	double	1
	OverallAirwayResistance	double	1
	TidalVolume	double	1
	DeadAirSpace	double	1
	RespiratoryRate	double	1
	LungCompliance	float	1
	InspiratoryCapacity	float	1
	VitalCapacity	float	1
	TotalLungCapacity	float	1
	InspiratoryReserveVolume	float	1
	ExpiratoryReserveVolume	float	1
	ResidualVolume	float	1
IrritantSensor	Location	string	1
	Status	string	1
TissueGroups	MetabolicRate	double	1
	pCO2Waste	double	1
	pO2Demand	double	1
	PeripheralResistance	double	1
	O2ExtractionCoefficient	double	1
	PercentCardiacOutput	float	1
	pO2ofTissueGrp	float	1
Epiglottis	status	string	1
Human	HemoglobinBindingPercent	float	1
	Age	double	1
	Weight	double	1
	Temperature	float	1
	HumanState	HumanStateData	1
	ShuntFactor	double	1
ArteryinBody	pO2In	double	1
	FlowRate	double	1
	Diameter	double	1
	pCO2In	float	1
Aorta	pO2In	double	1
	pCO2In	double	1
	FlowRate	double	1
	Diameter	double	1
VeininBody	FlowRate	double	1
	Diameter	double	1

Units	Resolution	Accuracy	Accuracy Condition
N/A	hundredths	perfect	always
inverse time (per minute)	hundredths	perfect	always
ml	hundredths	perfect	always
ml/min	hundredths	perfect	always
		perfect	always
	tenths	perfect	always
mm Hg	hundredths	perfect	always
cm3	tenths	perfect	always
		perfect	always
		perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
inverse time (per minute)	tenths	perfect	always
L/cm H2O	hundredths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
		perfect	always
		perfect	always
percentage	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
percentage	tenths	perfect	always
		perfect	always
		perfect	always
degrees Farenheit	tenths	perfect	always
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
mm Hg	tenths	perfect	always
	tenths	perfect	always
mm	tenths	perfect	always
mm Hg	tenths	perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
	tenths	perfect	always
	tenths	perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Static		N	UR
Conditional	If changed	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	TA	UR
Static		TA	UR
Static		TA	UR
Periodic	Every cycle	TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	If changed	N	UR
Periodic	Every cycle	N	UR
Conditional	Every cycle	N	UR
Conditional	If changed	N	UR
Static		N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Static		N	UR
Periodic	Every cycle	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Periodic	Every cycle	TA	UR
Periodic	Every cycle	TA	UR
Periodic	Every cycle	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Conditional	Upon change	TA	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	pO2Out	float	1
	pCO2Out	float	1
Pharynx	Diameter	float	1
Larynx	Diameter	float	1
Trachea	Diameter	float	1
Bronchia	Diameter	float	1
SpinalColumn	CerebrospinalFluidPH	double	1
NasalCavity	NasalCavityVolume	double	1
	FlowRate	float	1
ThoracicCavity	ThoracicCavityVolume	float	1
PleuralCavity	PleuralCavityVolume	double	1
Abdominal	ContractionLevel	double	1
ExternalIntercostals	ContractionLevel	float	1
InternalIntercostals	ContractionLevel	double	1
Diaphragm	ContractionLevel	double	1
LungConductingZone	AirwayResistance	double	1
LungRespiratoryZone	pO2staleBlood	double	1
	pCO2staleBlood	double	1
	pO2InspiredAir	double	1
	pCO2InspiredAir	double	1
	CO2DiffCoeff	double	1
	O2DiffCoeff	double	1
	pO2Out	double	1
	pCO2Out	double	1
	DMinverse	float	1
	MembraneSurfaceArea	float	1
	MembraneThickness	float	1
	AveolarVentilationRate	double	1
BAROAorticArch	Location	double	1
	Status	double	1
	BPChange	double	1
	DirectionBPChange	string	1
BAROCarotidSinus	Location	string	1
	Status	string	1
	BPChange	double	1
	DirectionBPChange	string	1
MedullPHRecpt	Location	string	1
	pHCerebroSpinalFluid	double	1
	Status	string	1
CarotO2Recpt	Location	string	1
	pO2	double	1
	Status	string	1
AorticO2Recpt	Location	string	1
	pO2	double	1
	Status	string	1
HeartValves	Position	string	1

Units	Resolution	Accuracy	Accuracy Condition
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm	tenths	perfect	always
mm	tenths	perfect	always
mm	tenths	perfect	always
mm	tenths	perfect	always
	hundredths	perfect	always
cm3	integer value	perfect	always
ml/min	integer value	perfect	always
cm3	integer value	perfect	always
cm3	hundredths	perfect	always
percentage	hundredths	perfect	always
percentage	tenths	perfect	always
percentage	hundredths	perfect	always
percentage	hundredths	perfect	always
		perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
ml/min/mm Hg	hundredths	perfect	always
ml/min/mm Hg	hundredths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
		perfect	always
cm2	tenths	perfect	always
mm	integer value	perfect	always
L/min	tenths	perfect	always
		perfect	always
		perfect	always
percentage	hundredths	perfect	always
		perfect	always
		perfect	always
		perfect	always
percentage	thousandths	perfect	always
		perfect	always
		perfect	always
	hundredths	perfect	always
N/A	N/A	perfect	always
		perfect	always
mm Hg	thousandths	perfect	always
N/A	N/A	perfect	always
		perfect	always
mm Hg	thousandths	perfect	always
		perfect	always
N/A	N/A	perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Periodic	Every cycle	TA	UR
Periodic	Every cycle	TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Static		N	UR
Conditional	If changed	N	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	TA	UR
Periodic	Every Cycle	N	UR
Periodic	Every cycle	TA	UR
Periodic	Every Cycle	TA	UR
Periodic	Every Cycle	TA	UR
Static		TA	UR
Static		TA	UR
Periodic	Every Cycle	TA	UR
Periodic	Every Cycle	TA	UR
Static		TA	UR
Static		TA	UR
Conditional	If changed	TA	UR
Periodic	Every Cycle	TA	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	If changed	N	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
HeartChambers	HeartChamberVolume	float	1
	EfficiencyofContraction	double	1
	pO2In	double	1
	pO2Out	double	1
	pCO2In	double	1
	pCO2Out	double	1
MedullaVasomotorReg	status	string	1
	activityState	string	1
	BPMonitorTissues	string	1+
MedullaCardioReg	status	string	1
	activityState	string	1
	BPHeartSysMonitor	string	1+
MedullaRespirReg	status	string	1
	activityState	any	1
InspiratoryCenter	CycleTime	float	1
ExpiratoryCenter	CycleTime	float	1
MedulCO2Recpt	Location	string	1
	Status	string	1
	pCO2	float	1
BodyEnvironMatrix	ExternalTemp	double	1
	AirPressure	double	1
	Altitude	double	1
	LocationData	LocationXY	1
	Humidity	double	1
	AirComponents	AirConstituentPercent	1
	BodyAffectors	string	1+
Federate	**FederateHost**	**string**	**1**
	FederateHandle	**string**	**1**
	FederateState	**string**	**1**
	FederateName	**string**	**1**
	RTIversion	**string**	**1**
	TimeManagerState	**string**	**1**
	FederateLookahead	**string**	**1**
	FederateTime	**string**	**1**
	TimeConstrained	**string**	**1**
	TimeRegulating	**string**	**1**
	FIFOlength	**string**	**1**
	TSOlength	**string**	**1**
	DequeueFIFOasync	**string**	**1**
	TotalObjectCount	**string**	**1**
	HoldingTokensObjectCou	**string**	**1**
	DeletedObjectCount	**string**	**1**
	NumAttributes	**string**	**1**
	NumParameters	**string**	**1**
Federation	**FederationName**	**string**	**1**
	FederationState	**string**	**1**

Units	Resolution	Accuracy	Accuracy Condition
cm3	integer value	perfect	always
percentage	integer value	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	thousandths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
sec	tenths	perfect	always
sec	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
degrees Farenheit	integer value	perfect	always
mm Hg	integer value	perfect	always
m	integer value	perfect	always
N/A	N/A	N/A	N/A
		perfect	always
N/A	N/A	N/A	N/A
mm Hg	tenths	perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Conditional	Every Cycle	N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	N	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	N	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	FederatesInFederation	**string**	1
	SaveIsScheduled	**string**	1
	ScheduledSaveTime	**string**	1
	RTIversion	**string**	1
ChangeCycleTime	Direction	string	1
	CycleChange	float	1
ConstrictBronchioles	Amount	float	1
TissDistressTrans	pO2TissGrp	float	1
	Location	string	1
	pCO2TissGrp	float	1
	whichProb	string	1
DecreaseHeartStrokeVolum	Amount	float	1
IncreaseHeartStrokeVolum	Amount	double	1
HStrokeVolumeDecrTrans	Amount	float	1
HStrokeVolumeIncrTrans	Amount	double	1
ChemPHParasymTrans	DecreaseInSV	float	1
	DecreaseInHR	float	1
ChemPHSympTrans	IncreaseInHR	float	1
	IncreaseInSV	float	1
RelaxTransA	Amount	double	1
RelaxTransB	Amount	double	1
ContractTransA	Amount	double	1
ContractTransB	Amount	double	1
ContractDiaphragm	Amount	double	1
ContractInternalIntercostals	Amount	double	1
ContractExternalIntercostal	Amount	float	1
ContractAbdominals	Amount	double	1
RelaxAbdominals	Amount	double	1
RelaxInternalIntercostals	Amount	double	1
RelaxExternalIntercostals	Amount	float	1
RelaxDiaphragm	Amount	double	1
ParasymHeartRateIncrease	Amount	float	1
IncreaseHeartRate	Amount	double	1
DecreaseHeartRate	Amount	double	1
ParasymIncreaseRate	Amount	float	1
IncreaseRate	Amount	double	1
DecreaseRate	Amount	double	1
DilateArtery	Amount	double	1
ConstrictArtery	Amount	double	1
ReturnToNormalpO2	pO2Value	float	1
LowpO2	pO2Value	double	1
IncreaseBP	Amount	double	1
	Location	string	1
DecreaseBP	Amount	double	1
	Location	string	1
AveolarIrritantSensed	Location	string	1

Units	Resolution	Accuracy	Accuracy Condition
		perfect	always
		perfect	always
		perfect	always
		perfect	always
N/A	N/A	perfect	always
sec	tenths	perfect	always
percentage	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage		perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
		perfect	always
		perfect	always
percentage	tenths	perfect	always
		perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
	integer value	perfect	always
	integer value	perfect	always
percentage	tenths	perfect	always
	integer value	perfect	always
	integer value	perfect	always
percentage	hundredths	perfect	always
percentage	hundredths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	perfect	always
percentage	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
BronchioleIrritantSensed	Location	string	1
LarynxIrritantSensed	Location	string	1
TrachealIrritantSensed	Location	string	1
TissDistressh	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressg	pO2ofTissGrp	float	1
	whichProblem	string	1
	pCO2ofTissGrp	float	1
TissDistressf	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistresse	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressd	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressc	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressb	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressa	pO2ofTissGrp	any	1
	whichProblem	string	1
	pCO2ofTissGrp	float	1
TracActIS	TurnOn	string	1
	LevelofIrritant	string	1
LaryActIS	TurnOn	string	1
	LevelofIrritant	string	1
BronActIS	TurnOn	string	1
	LevelofIrritant	string	1
AvelActIS	TurnOn	string	1
	LevelofIrritant	string	1
Alert	**AlertSeverity**	**string**	**1**
	AlertText	**string**	**1**
	AlertID	**string**	**1**
ServiceLogArguments	**Handle1**	**string**	**1**
	Handle2	**string**	**1**
	HandleSet	**string**	**1**
	ObjectIDorCount	**string**	**1**
	TagOrLabelOrName	**string**	**1**
	Time	**string**	**1**
	Enumeration	**string**	**1**
	Boolean	**string**	**1**

Units	Resolution	Accuracy	Accuracy Condition
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
		perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
		perfect	always
N/A	N/A	perfect	always
mm Hg	thousandths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
N/A	N/A	perfect	always
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**
		perfect	**always**

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
ObjectInformation	ObjectID	string	1
	LockedAttributes	string	1
	RegisteredClass	string	1
	RepresentedClass	string	1
PublishingClass	ObjectClass	string	1
	InteractionClass	string	1
SubscribingClass	ObjectClass	string	1
	InteractionClass	string	1
SetTiming	FedReportPeriod	string	1
	TimeReportPeriod	string	1
	ObjectReportPeriod	string	1
RequestObjectInformatio	ObjectID	string	1
ModifyAttributeState	ObjectID	string	1
	AttributeID	string	1
	TokenState	string	1
DoResignFederationExec	ResignAction	string	1
DoDeleteObject	ObjectID	string	1
	Time	string	1
	Tag	string	1
DoSetLookahead	Lookahead	string	1
DoSetTimeConstrained	State	string	1
Control	SetServiceLogging	string	1
	SetLogFile	string	1
	DeleteObject	string	1
	DequeueFIFO	string	1

Units	Resolution	Accuracy	Accuracy Condition
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
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		perfect	always
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		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Identifier	Enumerator	Representation
HumanStateData	Alive	1
	Dead	2

Complex Datatype	Field Name	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
LocationXY	X	float	1	m	integer valu	perfect	always
	Y	float	1	m	integer valu	perfect	always
AirConstituentPercent	COper	float	1	percentage	integer valu	perfect	always
	Argonper	float	1	percentage	integer valu	perfect	always
	O2per	float	1	percentage	integer valu	perfect	always
	CO2per	float	1	percentage	integer valu	perfect	always
	N2per	float	1	percentage	integer valu	perfect	always

Class	Component	Component
Larynx	Epiglottis	
CardiovascularSystem	HeartValves	
	Heart	HeartChambers
		HeartValves
	HeartChambers	
	CardiovascularDuctwork	
	HeartTissue	
RespiratorySystem	ThoracicCavity	
	RespiratoryDuctwork	
	LungConductingZone	
	LungRespiratoryZone	
	Lungs	LungRespiratoryZone
		LungConductingZone
		LungTissue
	LungTissue	
	PleuralCavity	
	RespiratoryMuscles	

Class	Association	Class
AorticO2Recpt	MemberPartnerA	VagusNV (Transmit info from s
CarotO2Recpt	MemberPartnerB	GlossopharyngealNV
BAROAorticArch	MemberPartnerC	VagusNV
BAROCarotidSinus	MemberPartnerD	GlossopharyngealNV
MedullPHRecpt	AssocStructureA	MedullaCardioReg
SympAbdomViscNV	Serves1	AbdomViscArtL
SympatheticCardiacNerve	Serves2	Heart
SympBronchialNV	Serves3	BronchialArt
SympCarotidNV	Serves4	CommonCarotidArtL
SympEsophgNV	Serves5	EsophagusTissue
SympExtIlliacNV	Serves6	ExternalIlliacArtR
SympIntIlliacNV	Serves7	InternalIlliacArtL
SympRenalNV	Serves	RenalArt
SympSubclavianNV	Serves9	SubclavianArtL
AbdominalNV	Serves10	AbdomParietArtL
GlossopharyngealNV	Serves11	Heart
IntercostalNV	Serves12	IntercostalArt
PhrenicNV	Serves13	Diaphragm
VagusNV	Serves14	Heart
PhrenicVein	Drains1	Diaphragm
AzygosVein	Drains2	EsophagusTissue
CoronaryVeinR	Drains3	HeartTissue
CoronaryVeinL	Drains4	HeartTissue
ExternalIlliacVeinR	Drains5	LowerLimbTissue
ExternalIlliacVeinL	Drains6	LowerLimbTissue
HepaticPortalVein	Drains7	AbdomViscera Tissue
InternalIlliacVeinL	Drains8	IntIlliacViscNParietTissue
InternalIlliacVeinR	Drains9	IntIlliacViscNParietTissue
JugularVeinsL	Drains10	HeadNeckSpineTissue
JugularVeinsR	Drains11	HeadNeckSpineTissue
SubclavianVeinL	Drains12	UpperLimbTissue
SubclavianVeinR	Drains13	UpperLimbTissue
InferiorVenaCava	Transports1	HepaticPortalVein
SuperiorVenaCava	Transports2	AzygosVein
LungRespiratoryZone	PulmonaryRt6	PulmonaryArteryL 2
LungRespiratoryZone	PulmonaryRt7	PulmonaryArteryR 2
AtriaRight	PulmonaryRt1	InferiorVenaCava
InferiorVenaCava	FormedBy1	InternalIlliacVeinL
BrachiocephalicVeinL	FormedBy2	SubclavianVeinL
BrachiocephalicVeinR	FormedBy3	SubclavianVeinR
VentricleRight	PulmonaryRt2	AtriaRight
PulmonaryTrunk	PulmonaryRt3	VentricleRight
PulmonaryArteryL 2	PulmonaryRt4	PulmonaryTrunk
PulmonaryArteryR 2	PulmonaryRt5	PulmonaryTrunk
PulmonaryVeinsL 2	PulmonaryRt8	LungConductingZone
PulmonaryVeinsR 2	PulmonaryRt9	LungRespiratoryZone
AtriaLeft	PulmonaryRt10	PulmonaryVeinsL 2

Class	Class	Class
AbdomViscArtR	AbdomViscera Tissue	
HeartTissue	CoronaryArteryL	CoronaryArteryR
LungTissue		
CommonCarotidArtR	HeadNeckSpineTissue	
EsophagealArt		
ExternalIliacArtL	LowerLimbTissue	
InternalIliacArtR	IntIliacViscNParietTissue	
KidneyTissue		
SubclavianArtR	UpperLimbTissue	
Abdominal	AbdomParietArtR	
InternalIntercostals	ExternalIntercostals	
SuperiorPhrenicArt		
InternalIntercostals	ExternalIntercostals	LungTissue
PhrenicVein	RenalVein	
BrachiocephalicVeinR	BrachiocephalicVeinL	
SuperiorVenaCava	CoronaryVeinR	CoronaryVeinR
InternalIliacVeinR	ExternalIliacVeinR	ExternalIliacVeinL
JugularVeinsL		
JugularVeinsR		

Class
Abdominal

Class	Association	Class
AtriaLeft	PulmonaryRt11	PulmonaryVeinsL 2
VentricleLeft	PulmonaryRt12	AtriaLeft
Aorta	PulmonaryRt13	VentricleLeft
PulmonaryTrunk	PulmonarySC1	CoronaryVeinR
PulmonaryArteryL 2	PulmonarySC2	PulmonaryTrunk
PulmonaryArteryR 2	PulmonarySC3	PulmonaryTrunk
LungRespiratoryZone	PulmonarySC4	PulmonaryArteryL 2
LungRespiratoryZone	PulmonarySC5	PulmonaryArteryR 2
PulmonaryVeinsL 2	PulmonarySC6	LungRespiratoryZone
PulmonaryArteryR 2	PulmonarySC7	LungRespiratoryZone
Aorta	PulmonarySC8	PulmonaryVeinsL 2
Aorta	PulmonarySC9	PulmonaryArteryR 2
AorticArch	SystCircDel1	Aorta
DescendingAorta	SystCircDel2	Aorta
AscendingAorta	SystCircDel3	Aorta
CoronaryArteryL	SystCircDel4	AscendingAorta
CoronaryArteryR	SystCircDel5	AscendingAorta
BrachiocephalicArt	SystCircDel6	AorticArch
CommonCarotidArtL	SystCircDel7	AorticArch
SubclavianArtL	SystCircDel8	AorticArch
CommonCarotidArtR	SystCircDel9	BrachiocephalicArt
SubclavianArtR	SystCircDel10	BrachiocephalicArt
AbdomParietArtL	SystCircDel11	DescendingAorta
AbdomParietArtR	SystCircDel12	DescendingAorta
AbdomViscArtL	SystCircDel13	DescendingAorta
AbdomViscArtR	SystCircDel14	DescendingAorta
BronchialArt	SystCircDel15	DescendingAorta
EsophagealArt	SystCircDel16	DescendingAorta
IliacArtL	SystCircDel17	DescendingAorta
IliacArtR	SystCircDel18	DescendingAorta
IntercostalArt	SystCircDel19	DescendingAorta
RenalArt	SystCircDel20	DescendingAorta
SuperiorPhrenicArt	SystCircDel21	DescendingAorta
InternalIliacArtL	SystCircDel22	IliacArtL
ExternalIliacArtL	SystCircDel23	IliacArtL
ExternalIliacArtR	SystCircDel24	IliacArtR
InternalIliacArtR	SystCircDel25	IliacArtR
AbdomVisceraTissue	Supplied1	AbdomViscArtL
AbdomVisceraTissue	Supplied2	AbdomViscArtR
Diaphragm	Supplied3	SuperiorPhrenicArt
EsophagusTissue	Supplied4	EsophagealArt
HeadNeckSpineTissue	Supplied5	CommonCarotidArtL
HeadNeckSpineTissue	Supplied6	CommonCarotidArtR
HeartTissue	Supplied7	CoronaryArteryL
HeartTissue	Supplied8	CoronaryArteryR
IntIliacViscNParietTissue	Supplied9	InternalIliacArtR
IntIliacViscNParietTissue	Supplied10	InternalIliacArtL

Class	Class	Class
CoronaryVeinL	InferiorVenaCava	SuperiorVenaCava

Class

Class	Association	Class
KidneyTissue	Supplied11	RenalArt
LowerLimbTissue	Supplied12	ExternalIlliacArtL
LowerLimbTissue	Supplied13	ExternalIlliacArtR
LungTissue	Supplied14	BronchialArt
UpperLimbTissue	Supplied15	SubclavianArtR
UpperLimbTissue	Supplied16	SubclavianArtL
ExpiratoryCenter	Reciprocal	InspiratoryCenter
Pneumotaxic/IntegrationCenter	MonitorsNIntegrates	MedullaVasomotorReg
Pneumotaxic/IntegrationCenter	Reset	ExpiratoryCenter

Class	Class	Class
MedullaCardioReg		
InspiratoryCenter		

Class

Term	Definition
MedullaRegulatoryCenter	The functional view of the medulla as a regulator of important body functions involving
OrganicDuctwork	organic conduits in the body
NervousDuctwork	nervous system fiber (nerves)
RespiratoryDuctwork	conduits in the respiratory system
CardiovascularDuctwork	conduits in the cardiovascular system
Organs	Body parts that are usually classed as organs
Heart	The pump of the body. It has components.
Lungs	major organ of respiration
OrganicRCPTRS	organic type sensors in the body
ChemoReceptor	sensor to sense pH or pO2 or pCO2 levels in the blood or cerebrospinal fluid
BaroReceptor	sensor to sense pressure changes in arteries
IrritantSensor	Senses physical irrritant, such as ash particle.
TissueGroups	body tissue arranged by groups and defined according to what artery feeds the tissue
Cavities	body part involving a spatial region which is connected to another by an opening
Chambers	body part region involving open or semi-open space which may be filled
Valves	body part mimicing a mechanical valve
Epiglottis	unpaired cartilege ; a part of the larynx, that flaps open or closed
LumpedZones	Sections of the body that are partitioned for calculations involving some subsytem suc
Human	overal entity associated with the body SOM
ArteryinBody	conduit which carries blood away from the heart
Aorta	primary artery of the body from which all other arteries descend, the aorta is 2.8 cm in
VeininBody	conduit which carries blood to the heart
Pharynx	Body part- common opening of the respiratory and digestive tracts
Larynx	Body part-nine joined cartilege rings that form part of the upper respiratory system
Trachea	body part– the windpipe–a tubular part of the upper respiratory system–follows the lar
Bronchia	tubular branching passageway part of the respiratory system
SympAbdomViscNV	Sympathetic nerve going to the abdominal viscera artery – involved in vasomotor com
SympEsophgNV	Sympathetic nerve going to the esophageal artery – involved in vasomotor commands
SympCarotidNV	Sympathetic nerve going to the carotid arteries – involved in vasomotor commands
SympSubclavianNV	Sympathetic nerve going to the subclavian artery; involved in vaomotor commands.
SympIntIlliacNV	Sympathetic nerve going to the Internal Illiac arteries– involved in vasomotor comman
SympExtIlliacNV	Sympathetic nerve which goes to the external illiac arteries; involved in vasomotor co
SympRenalNV	Sympathetic nerve going to the kidney artery; involved in vasomotor commands to art
SympBronchialNV	Sympathetic nerve which goes to the Lung Tissue Bed artery; involved in vasomotor
SympatheticCardiacNerve	nerve running to the heart – sympathetic stimulation nerve.
AbdominalNV	nerve ennervating the abdominal muscle/ tissue group. important for respiration.
IntercostalNV	Nerve going to the intercostal muscle–important in respiration.
GlossopharyngealNV	nerve running to the heart
PhrenicNV	nerve running to the diaphragm–important in respiration.
VagusNV	nerve running to the heart
SpinalColumn	nerves associated with the spinal column; like telephone cables
NasalCavity	cavity between the nostrils of the nose and the pharynx
ThoracicCavity	Cavity area of thorax in the physical human body. Lungs situated in this cavity. this ca
PleuralCavity	potential space between the parietal and visceral layers of the pleura
UpperLimbTissue	Tissue group served by subclavian arteries, left and right.
HeadNeckSpineTissue	Tissue group served by common carotid arteries, left and right.
LowerLimbTissue	Tissue group served by external illiac arteries, left and right.

Term	Definition
IntIlliacViscNParietTissue	Tissue group served by the internal illiac arteries, right and left.
AbdomViscera Tissue	Tissue group served by AbdomViscArt left and right, the abdominal viscera arteries. Ie
KidneyTissue	Tissue group served by the renal artery.
HeartTissue	Muscle tissue group that is the heart, served by the coronary arteries left and right.
EsophagusTissue	Tissue group served by the esophegeal artery.
LungTissue	Tissue group served by the bronchial artery.
RespiratoryMuscles	muscles used in inhaling and exhaling
Abdominal	Tissue (muscle) served by the Abdominal Parietal Arteries, left and right. This is a m
ExternalIntercostals	Muscles involved in inspiration;elevates the ribs. Served by the intercostal artery .
InternalIntercostals	Muscle tissue group also served by the Intercostal Art, the intercostal artery. This i
Diaphragm	Muscle tissue served by the superior Phrenic artery. This is a muscle of respiration.
CO2Sensor	Chemo sensor to sense CO2 levels in the blood or cerebrospinal fluid.
PHSensor	Sensor class to determine pH of blood or of cerebrospinal fluid.
O2Sensor	General class of sensor to determine partial pressure of O2.
ExternalIlliacArtR	This artery serves the right lower limb.
ExternalIlliacArtL	This artery serves the left lower limb.
InternalIlliacArtR	This artery serves the right pelvis rand right lower back
InternalIlliacArtL	This artery serves the left pelvis and left lower back region
IlliacArtR	this is the common illiac artery right which is formed by the split of the descending aort
IlliacArtL	this is the left common illiac artery; it is a continuation of the descending aorta at the a
AbdomParietArtL	serves the back muscles and the abdominal walls on the left
AbdomParietArtR	supplies the abdominal wall and the back region on the right
AbdomViscArtL	serves the left abdominal viscera tissues; except for the kidneys
AbdomViscArtR	artery serves abdominal viscera; right side; except for the kidneys
RenalArt	Serves the kidney tissue group.
EsophagealArt	Serves the esophagus tissue group, carries oxygen.
IntercostalArt	serves the intercostal muscle tissue, carries oxygen.
BronchialArt	Seves the lung tissue group, carries oxygen.
SuperiorPhrenicArt	serves the diaphragm muscle tissue group, carries oxygen
SubclavianArtL	This artery is the third branch off of the aortic arch. It transports blood to the upper lim
CommonCarotidArtL	This artery branches off of the aortic arch. It transports blood to the left side of the hea
SubclavianArtR	This branches off of the brachiocephalic artery and transpots blood to the upper limb (
CommonCarotidArtR	This artery branches from the brachiocephalic artery , and transports blood to the right
BrachiocephalicArt	first vessel(artery) to branch from the aortic arch; if branches to form the right common
CoronaryArteryR	the right branch of the ascending aorta
CoronaryArteryL	the left branch of the ascending aorta, serves the heart tissue left side
PulmonaryArteryR	artery which bifurcates off of the pulmonary trunk in the right direction and carries bloo
PulmonaryArteryL	artery which bifurcates off of the pulmonary trunk in the left direction and carries blood
PulmonaryTrunk	short arterial vessel (5 cm long) which comes off of the right ventricle of the heart; an
LungConductingZone	Bulk flow part of airways; no gas exchange
LungRespiratoryZone	Conceptual part of the respiratory system; a natural partition into which falls the attribu
DescendingAorta	the descending branch off of the aorta
AscendingAorta	the ascending branch off of the aorta
AorticArch	the branching of the aorta posteriorly and to the left which forms an arch shape
InternalIlliacVeinR	Drains the IntIlliacViscNParietTissue right side, and joins with the external illiac vein ri
InternalIlliacVeinL	Drains the IntIlliacViscNParietTissue left side, and joins with the external illiac vein to f
ExternalIlliacVeinR	Drains the lower limb tissue group right side, and unites with the internal illiac to ultima

Term	Definition
ExternalIlliacVeinL	Drains the lower limb tissue group –left side.
SuperiorVenaCava	Transport Vein. Major conduit returning blood from the azygos , the right and left brac
InferiorVenaCava	Transport Vein. Vein conduit into heart which is formed by the illiac veins, and returns
RenalVein	drains the kidney tissue group. Empties into the inferior vena cava transport vein.
PhrenicVein	Drains the diaohragm muscle tissue group; empties into the inferior vena cava, a trans
HepaticPortalVein	Drains the AbdomViscera Tissue group, empties into the inferior vena cava, a transpor
AzygosVein	Drains the Esophagus Tissue group, the Intercostal Tissue groups, the lung tissue, a
BrachiocephalicVeinR	Transport vein – returns blood to the superior vena cava from the right side.
BrachiocephalicVeinL	transport vein – to the superior vena cava (from left)
SubclavianVeinR	Drains the Upper Limb Tissue (right side) and joins with the right jugular vein to form
SubclavianVeinL	vein draining upper limb tissue (left) ; it joins with the jugular vein (L) to form left brach
JugularVeinsR	drains HeadNeckSpine tissue group (right side) . Joins with the subclavian vein (right)
JugularVeinsL	Drains HeadNeckSpine tissue group (left side). Joins with the subclavian vein to for
PulmonaryVeinsR	right pulmonary veins (2) carrying blood from the lung to the right atrium of the heart ;
PulmonaryVeinsL	left pulmonary veings (2) carrying blood from the lungs to the left atrium
CoronaryVeinR	transport blood from heart tissue (right side) to the right atrium
CoronaryVeinL	transports blood from heart tissue (left side) to the right atrium of the heart
BAROAorticArch	The pressure sensor for the aortic arch.
BAROCarotidSinus	The pressure sensor for the carotid sinous body.
MedulPHRecpt	pH sensor in the medulla; senses thepH of cerebrospinal fluid.
CarotO2Recpt	The O2 sensor in the carotid body.
AorticO2Recpt	The O2 sensor in the aorta
HeartValves	Valves found in the physical human heart.
AorticSemiLunarValve	valve in physical human heart between the left ventricle and the aorta; opens to let flo
PulmonarySemiLunarValve	valve in the physical human heart beween the right ventricle and the pulmonary trunk
MitralValve	Valve in the physical human heart between the left atrium and the left ventricle. Blood
TricuspidValve	Valve in the physical human heart between also between the right ventricle and the pu
HeartChambers	Chamber - like areas in the heart
VentricleLeft	Chamber in the physical human heart.
VentricleRight	Chamber in the physical human heart.
AtriaLeft	Chamber in the physical human heart
AtriaRight	Chamber in the physical human heart
MedullaVasomotorReg	The medulla's vasomotor regulatory center.
MedullaCardioReg	The medulla's cardio regulatory center
MedullaRespirReg	The medulla' s respiratory regulatory system.
InspiratoryCenter	A type of respiratory center in the medulla
ExpiratoryCenter	A type of respiratory center in the medulla
Pneumotaxic/IntegrationCe	A type of respiratory center in the medulla; it modifies the length of the cycle time (bre
MedulCO2Recpt	The CO2 sensor in the medulla receive compute send region
CardiovascularSystem	The physiological system in the human body pertaining to blood flow through the heart
RespiratorySystem	Physiological system pertaining to breathing and oxygenation; an abstract class comp
AveolarIrritantSensor	Biological sensor (cells) in the Lung REspiratory Zone which sense the presense of irr
BronchioleIrritantSensor	Biological sensors (cells) in the RemainingBronchiaNetwork which sense the presenc
LarynxIrritantSensor	Biological sensors (cells) in the larynx which sense the presense of irritants such as a
TrachealIrritantSensor	Biological sensor (cells) in the trachea which sense the presence of irritants such as
BodyEnvironMatrix	The environmental factors surrounding the body
MedullRecvSendCompute	The overal medulla

Term	Definition
Manager	Manager class for the management object model.
Federate	Manager subclass for federates specific information.
Federation	Manager subclass for federation specific information.

Term	Definition
StartExpiratory	Message to start the expiratory sequence
CeaseInhale	When the epiglottis closes, the inhalation ceases.
InflationMaximum	The lungs are at their maximum inflation
ChangeCycleTime	Modify the breathing period for the recipient center
OpenEpiglottis	Message to open the epiglottis;used in respiration
CloseEpiglottis	Message to close the epiglottis; used in the cough sequence.
ConstrictBronchioles	The effective diameter of the Bronchia is being reduced due to the presence of an irrit
IrritantSensed	interaction superclass whose subclasses are specific interactions communicating that
IrrSensorActivated	One of the irritant sensors has been activated by particulate matter hitting it
ChangeArteryDiameterCom	interaction to change the diameter of an artery. this affects the flow rate
TissDistressTrans	Transmitting of the tissue distress signal from the sympathetic nerve to the vasomotor
TissueDistress	This interaction involves the tissue groups needs for oxygen and waste (CO_2) eliminat
DecreaseHeartStrokeVolum	Command to decrease the heart stroke volume; from parasympathetic nervous syste
IncreaseHeartStrokeVolum	command to change the stroke volume of the heart-- from sympathetic cardiac erve t
HStrokeVolumeDecrTrans	transmission from the cardio reg center in the medulla to the parasympathetic nerve g
HStrokeVolumeIncrTrans	message from medulla to sympathetic cardiace nerve to relay message to heart chan
HeartRateCommand	message from nerves to heart to change the heart rate
HeartRateTrans	message from medulla to specfic nerves to relay message to heart to change the hear
ChemPHParasymTrans	Message transmitted from the medulla to the parasym nerves going to the heart; due t
ChemPHSympTrans	Transmission of data from the medulla as a result of pH too low (CO_2 too high) from s
RelaxTransA	message from inspiratory center to specific nerves involved in inspiration to relay a rel
RelaxTransB	Transmitted message from expiratory center to nerves involved in expiration to relax
ContractTransA	message from inspiratory center to specific nerves involved in inspiration to tell them t
ContractTransB	Message from expiratory center to nerves involved in expiration to contract.
Relax	a m,essage to relax the muscles--increase the length
Contract	a message to contract the muscles--lessen the length
ContractDiaphragm	message to contract the diaphragm muscles --used in breathing
ContractInternalIntercostals	message to contract the internal intercostal muscles used in breathing--the expiratory
ContractExternalIntercostal	Contract the external intercostals--muscles used for the inspiratory part of breathing
ContractAbdominals	message to abdominal muscles to contract -- these muscles used in breathing
RelaxAbdominals	a message to relax the abdominal muscles -- used in breathing
RelaxInternalIntercostals	a message to relax the intercostal muscles --used in breathing
RelaxExternalIntercostals	Relax the external intercostal muscles -- used in inspiration (breathing in)
RelaxDiaphragm	a message to relax the diaphragm muscles -- used in breathing
ParasymHeartRateIncrease	Transmission of message from cardio reg center to vagus nerve saying increase the h
IncreaseHeartRate	command to increase the beats per minute of the heart
DecreaseHeartRate	command to heart to decrease the beats per minute
ParasymIncreaseRate	Transmit message for an increase in heart rate thru the parasympathetic system, to ef
IncreaseRate	instruction for nerve to relay to increase the beats per minute of the heart
DecreaseRate	instruciton for nerve to relay to decrease the beats per minute
DilateArtery	Decrease artery diameter -- vasomotor response
ConstrictArtery	Artery diameter is decreasing--vasomotor response.
ReturnToNormalpO2	The pO_2 is high relative to its forerly too low value as measured by the aortic pO_2 sen
LowpO2	partial pressure of O_2 is low as measured by O_2 sensors in either the aortic body sen
IncreaseBP	Message that an increase in blood pressure is occurring.
DecreaseBP	Message that a decrease in blood pressure is occurring.
AveolarIrritantSensed	Presense of an irritant is communicated

Term	Definition
BronchioleIrritantSensed	presence of an irritant is communicated
LarynxIrritantSensed	presence of an irritant is communicated
TrachealIrritantSensed	presence of an irritant is communicated
TissDistressh	Lung tissue distress due to low oxygen or high CO2
TissDistressg	Esophegeal tissue distress due to low oxygen or high CO2
TissDistressf	Kidney tissue group distress due to low oxygen or high CO2
TissDistresse	Abdominal viscera tissue group distress due to low oxygen or high carbon dioxide
TissDistressd	Tissue group including visc and parietal served by the internal illiac artery distress due
TissDistressc	Low O2 or high CO2 distress in lower limb tissue
TissDistressb	Tissue distress call - not enough oxygen or too much carbon dioxide -- -in the head,ne
TissDistressa	The oxygen in the upper limb tissue group is too low, or the carbon dioxide is too high
TracActIS	The irritant sensor in the trachea is activated by the presence of particulates
LaryActIS	The irritant sensor in the larynx is activated by the presence of particulates
BronActIS	The bronchia irritant sensor is activated by the presence of particulates.
AvelActIS	The aveolar irritant sensor has been activited by particulates hitting it
Manager	**The Manager interaction group contains all Management Object Model interactio**
Federate	**The Manager::Federate interaction group contains all MOM interactions associa**
Alert	**The Manager::Federate::Alert interaction allows the RTI to inform the federation**
ServiceLog	**The Manager::Federate::ServiceLog interaction allows detailed tracing of RTIam**
ServiceLogArguments	**The Manager::Federate::ServiceLog::ServiceLogArguments interaction allows d**
ObjectInformation	**The Manager::Federate::ObjectInformation interaction is sent by the RTI in resp**
PublishingClass	**The Manager::Federate::PublishingClass interaction is sent by the RTI in respon**
SubscribingClass	**The Manager::Federate::SubscribeClass interaction is sent by the RTI in respon**
Action	**The Manager::Federate::Action interaction is used to preform an action on a re**
RequestPublicationTree	**The Manager::Federate::RequestPublicationTree is used to request that the RTI**
RequestSubscriptionTree	**The Manager::Federate::RequestSubscriptionTree interaction is used to reques**
SetTiming	**The Manager::Federate::SetTiming interaction allows modification of a federate'**
RequestObjectInformatio	**The Manager::Federate::Action::RequestObjectInformation interaction causes t**
ModifyAttributeState	**The Manager::Federate::Action::ModifyAttributeState interaction allows federat**
RemoteServiceInvocation	**The Manager::Federate::Action::RemoteServiceInvocation interaction group co**
DoResignFederationExec	**The Manager::Federate::Action::RemoteServiceInvocation::DoResignFederation**
DoDeleteObject	**The Manager::Federate::Action::RemoteServiceInvocation::DoDelete interactio**
DoSetLookahead	**The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead in**
DoSetTimeConstrained	**The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead in**
DoTurnRegulationOn	**The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationO**
DoTurnRegulationOff	**The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationO**
Control	**The Manager::Federate::Action::Control interaction is used to set service loggin**

Class/Interaction	Term	Definition
NervousDuctwork	TransmissionFactor	Number between zero and one, inclusive, which degrades information p
Heart	HeartRate	beats per minute
	StrokeVolume	volume of blood pumped out of one ventricle of the heart in a single bea
	CardiacOutput	volume of blood pumper by the heart per minute
	PeripheralResistanc	total peripheral resistance from artery to capillaries
	ForceOfContraction	force with which the heart ventricle contracts in the pumping cycle
	BloodPressure	pressure of the blood in the blood vessels
Lungs	LungVolume	internal volume of the physical lungs (balloon like part)
	InternalLungPressur	air pressure inside the lungs; called intrapulmonary pressure also.
	OverallAirwayResist	resistance to airflow in the respiratory system
	TidalVolume	volume of air inhaled or exhaled during a regular breath
	DeadAirSpace	volume of respiratory system in which gas exchange does not take plac
	RespiratoryRate	breaths per minute
	LungCompliance	Volume change per unit change of pressure
	InspiratoryCapacity	The tidal volume plus the inspiratory reserve volume, about 3000 ml.
	VitalCapacity	The sum of the tidal volume, inspiratory reserve, and expiratory reserve
	TotalLungCapacity	The sum of the inspiratory reserve, expiratory reserve, tidal volume, an
	InspiratoryReserveV	The volume of air remaining after expiration of normal tidal volume; abo
	ExpiratoryReserveV	The volume of air remaining afer forced expiration of normal tidal volum
	ResidualVolume	Volume of air remaining after most forceful expiration, about 1200 ml.
IrritantSensor	Location	Anatomical location of the irritant sensot
	Status	The status is "ON" or "OFF"
TissueGroups	MetabolicRate	basal metabolism rate, consumption of O2 needed to maintain activities
	pCO2Waste	partial pressure of carbon dioxide in tissue groups
	pO2Demand	the partial pressure of oxygen needed for activity
	PeripheralResistanc	resistance to the flow of blood thru the tissue group; affects the blood pr
	O2ExtractionCoeffici	the coefficient of diffusion for oxygen across the membranes into the tis
	PercentCardiacOutp	The percentage of the total cardiac output that is being used by the tiss
	pO2ofTissueGrp	The actual partial pressure of oxygen of the tissue group
Epiglottis	status	OPEN or CLOSED are the two states that the epoglottis can be in
Human	HemoglobinBindingP	Percentage of hemoglobin sites that can be bound with O2 ; CO will st
	Age	how old the human body is
	Weight	the weight in a 1 g field
	Temperature	Temperature of the human
	HumanState	State of the human; only bsic states represented; alive or dead via an e
	ShuntFactor	Percentage of blood that is never oxgenated
ArteryinBody	pO2In	partial pressure of oxygen into artery
	FlowRate	rate of flow
	Diameter	diameter of artery
	pCO2In	partial pressure of carbon dioxide in the artery
Aorta	pO2In	partial pressure of oxygen into aorta
	pCO2In	partial pressure of carbon dioxide into the aorta
	FlowRate	flow rate of blood thru aorta
	Diameter	diameter of aorta
VeininBody	FlowRate	flowrate of blood in vein
	Diameter	diameter of vein
	pO2Out	partial pressure of oxygen in the vein – carried out and away from the ti

Class/Interaction	Term	Definition
	pCO2Out	partial pressure of carbon dioxide in the vein -- blood being carried out a
Pharynx	Diameter	Effective Diameter of the pharynx, assuming a more or less circular cro
Larynx	Diameter	The effective diameter of the larynx (more or less circular cross section
Trachea	Diameter	The effective diameter of the windpipe with a circular cross sectional sh
Bronchia	Diameter	Effective diameter (organic conduit shape approximated by a circle) of t
SpinalColumn	CerebrospinalFluidP	pH of the spinal fluid
NasalCavity	NasalCavityVolume	Volume of the nasal cavity
	FlowRate	Rate of air flow in the nasal cavity
ThoracicCavity	ThoracicCavityVolu	Volume of the thoracic cavity; it changes with respiration, and must be
PleuralCavity	PleuralCavityVolume	physical volume of the pleural cavity
Abdominal	ContractionLevel	percentage of maximum contraction
ExternalIntercostals	ContractionLevel	Percentage of contraction
InternalIntercostals	ContractionLevel	percentage of maximum contraction
Diaphragm	ContractionLevel	Percentage of maximum contraction
LungConductingZon	AirwayResistance	resistance to the flow of air through the airway passages which decreas
LungRespiratoryZon e	pO2staleBlood	partial pressure of O2 in the "used" blood which is flowing in capillaries
	pCO2staleBlood	partial pressure of carbon dioxide in the used blood before it flows near
	pO2InspiredAir	partial pressure of oxygen in the air that is breathed in.
	pCO2InspiredAir	partial pressure of carbon dioxide in the air that is breathed in
	CO2DiffCoeff	diffusion coefficient of carbon dioxide through the capillary wall.
	O2DiffCoeff	Diffusion coefficient of O2 across the capillary wall.
	pO2Out	partial pressure of oxygen leaving he lung respiratory zone
	pCO2Out	partial pressure of carbon dioxide leaving the lung respiratory zone
	DMinverse	Diffusion resistance of the avelolcapillary membrane.
	MembraneSurfaceAr	Effective surface area of the respiratory membrance across which the g
	MembraneThickness	Thickness of the respiratory membrane
	AveolarVentilationRa	Good measure of air flow volume per minute; is the respiratory rate time
BAROAorticArch	Location	Physical location of sensor
	Status	"ON" or "OFF"
	BPChange	Change in blood pressure
	DirectionBPChange	"INCREASE" or "DECREASE"
BAROCarotidSinus	Location	Physical location of sensor
	Status	"ON" or "OFF"
	BPChange	Change in the blood pressure -- the delta.
	DirectionBPChange	"INCREASE" or "DECREASE"
MedullPHRecpt	Location	Physical location of sensor
	pHCerebroSpinalFlui	The pH of the cerebrospinal fluid.
	Status	"ON" or "OFF"
CarotO2Recpt	Location	Physical location of sensor
	pO2	The partial pressure of O2.
	Status	"ON" or "OFF"
AorticO2Recpt	Location	Physical location of sensor.
	pO2	The partial pressure of oxygen.
	Status	"ON" or "OFF"
HeartValves	Position	OPEN or CLOSED
HeartChambers	HeartChamberVolu	Volume of the heart chamber
	EfficiencyofContracti	The efficiency with which a chamber contracts

Class/Interaction	Term	Definition
	pO2In	Parital pressure of O2 of the blood entering the chamber
	pO2Out	Partial pressure of O2 in the blood leaving the chamber -- should be sa
	pCO2In	Partial pressure of CO2 in blood entering the chamber
	pCO2Out	Partial pressure of CO2 in blood leaving teh chamber --should be the sa
MedullaVasomotorReg	status	the state of the regulatory center
	activityState	Qualitative level of activity in the state
	BPMonitorTissues	The vasomotor center serves to track the tissue blood pressures; gives
MedullaCardioReg	status	The state of the regulatory center
	activityState	Qualitative level of activity in the state
	BPHeartSysMonitor	Serves to keep track of the blood pressure in the core as opposed to th
MedullaRespirReg	status	The state of the regulatory center
	activityState	Qualitative level of activity in the state
InspiratoryCenter	CycleTime	The length of the time that the center can be actively sending out mess
ExpiratoryCenter	CycleTime	The lenght of time that the center can be actively sending out messages
MedulCO2Recpt	Location	Physical location of the sensor
	Status	"ON" or "OFF"
	pCO2	partial pressure of CO2 in the location of the sensor as mesured by the
BodyEnvironMatrix	ExternalTemp	The ambient temp in the surrounding environment
	AirPressure	The pressure of the ambient environment
	Altitude	Height above sea level
	LocationData	The physical location of the body measured with respect to some specif
	Humidity	Amount of water vapor in the air
	AirComponents	The constituent gases of the ambient atmosphere
	BodyAffectors	Any additional inputs (stimuli) which affect the body
Federate	**FederateHost**	**The string representation of the hostname the federate is executin**
	FederateHandle	**The string representation of an integer that is the handle assigned**
	FederateState	**The string representation of the integer corresponding to the value**
	FederateName	**The string representation of the name speified by the federate at jo**
	RTIversion	**The string representation of the software version of the TRI library.**
	TimeManagerState	**The string representation of the integer correpsonding to the value**
	FederateLookahea	**The string representation of a double that is the value of the feder**
	FederateTime	**The string representation of a double that is the value of the federa**
	TimeConstrained	**The character representation of an integer that specifies whether t**
	TimeRegulating	**The character representation of an integer that specifies whether t**
	FIFOlength	**The string representation of an integer that specifies the number o**
	TSOlength	**The string representation of an integer that specifies the number o**
	DequeueFIFOasyn	**The string representation of the boolean value indicating whether**
	TotalObjectCount	**The string representation of an integer that specifies the total nu**
	HoldingTokensObj	**The string representation of an integer that specified the number**
	DeletedObjectCoun	**The string representation of an integer that specifies the number o**
	NumAttributes	**The string representation of an integer that acts as an indicator of**
	NumParameters	**The string representation of an integer that acts as an indicator of**
Federation	**FederationName**	**The string name of the federation.**
	FederationState	**The string representation of the integral value of the RTI::Federati**
	FederatesInFederat	**The string representation of the integral number of federates joine**
	SaveIsScheduled	**The string representation of the boolean value indicating whether**
	ScheduledSaveTim	**The string representation of the double-precision floating-point nu**

Class/Interaction	Term	Definition
	RTIversion	**The string representation of the version number of the federation e**
ChangeCycleTime	Direction	The direction "PLUS" or MINUS" of the change in the cycle time
	CycleChange	The change in seconds of the cycle time
ConstrictBronchioles	Amount	Value of change in effective diameter expresssed in percentage of nomi
TissDistressTrans	pO2TissGrp	The actual pO2 of the tissue group in distress
	Location	Origination of the distress signal -- ie, the tissue group
	pCO2TissGrp	Actual pCO2 of the tissue group in distress
	whichProb	String indicating whether problem is low O2,high CO2, or both
DecreaseHeartStrok	Amount	Magnitude of decrease measured in percentage of current value
IncreaseHeartStroke	Amount	magnitude of the force fo contraction expressed as a percentage of curr
HStrokeVolumeDecr	Amount	Magnitude of the decrease -- measured in percentage of current value
HStrokeVolumeIncrT	Amount	magnitude of force of contraction expressed as a percentage of current
ChemPHParasymTr	DecreaseInSV	Percentage decrease in stroke volume of heart
ans	DecreaseInHR	Percentage decrease in heart rate.
ChemPHSympTrans	IncreaseInHR	percentage increase in HR
	IncreaseInSV	percentage increase in Stroke Volume of heart
RelaxTransA	Amount	magnitude based as a percentage of the maximum
RelaxTransB	Amount	Magnitude of relaxation expressed as a percentage
ContractTransA	Amount	Magnitude expressed as a percentage of the maximum
ContractTransB	Amount	Magnitude of contraction expressed as percentage
ContractDiaphragm	Amount	magnitude expressed as a percentage of the maximum
ContractInternallnter	Amount	magnitude expressed as a percentage of the maximum
ContractExternallnte	Amount	Percentage change
ContractAbdominals	Amount	magnitude based as a percentage of the maximum
RelaxAbdominals	Amount	magnitude expressed as a percentage of the maximum
RelaxInternalInterco	Amount	magnitude expressed as a percentage of maximum
RelaxExternalInterco	Amount	Percentage of relaxation
RelaxDiaphragm	Amount	magnitude expressed as a percentage of the maximum
ParasymHeartRatel	Amount	percentage increase in present heart rate to effect a return to normal
IncreaseHeartRate	Amount	number of beats/min to increase heart rate
DecreaseHeartRate	Amount	number of beats per minute to decrease
ParasymIncreaseRa	Amount	Percentage increase in heart rate to effect a return to noremal
IncreaseRate	Amount	number of beats per minute to increase the heart rate
DecreaseRate	Amount	number of beats per minute to decrease the heart rate
DilateArtery	Amount	Percentage decrease in artery diameter from current diameter
ConstrictArtery	Amount	percentage constriction relative to current diameter of the artery
ReturnToNormalpO2	pO2Value	partial pressure of O2 value in the location of the sensor
LowpO2	pO2Value	the value of the partial pressure of O2 as measured by the appropriate
IncreaseBP	Amount	Magnitude of increase in blood pressure.
	Location	Site of report of blood pressure increase
DecreaseBP	Amount	Magnitude of blood pressure decrease.
	Location	Location of the blood pressure sensor
AveolarIrritantSense	Location	Physical loation of the aveolar irritant sensor -- is in the LungRespirator
BronchioleIrritantSen	Location	Physical location of irritant sensor -- is in the RemainingBronciaNetwork
LarynxIrritantSensed	Location	Physical location of the irritant sensor
TrachealrritantSens	Location	Physical location of the irritant sensor that's sensing the stimuli.
TissDistressh	pO2ofTissGrp	Acutal pO2 of lung tissue

Class/Interaction	Term	Definition
	pCO2ofTissGrp	Actual pCO2 of tissue group
	whichProblem	String specifing if the tissue distress is due to low pO2 or high pCO2 or
TissDistressg	pO2ofTissGrp	Actual pO2 of esophegeal tissue
	whichProblem	String indicating which is the problem, high CO2, low O2, or both
	pCO2ofTissGrp	Actual pCO2 of the esophegeal tissue group
TissDistressf	pO2ofTissGrp	Actual pO2 of the kidney tissue
	pCO2ofTissGrp	Actual pCO2 of the kidney tissue
	whichProblem	String indicating if low oxygen, high carbond dioxde, or both are the pro
TissDistresse	pO2ofTissGrp	Actual pO2 of the abdominal viscera tissue group.
	pCO2ofTissGrp	Actual pCO2 of abdominal viscera tissue group
	whichProblem	String indicating if problem is low O2, high CO2, or both
TissDistressd	pO2ofTissGrp	Actual pO2 of the tissue group that is served by the internal illiac artery
	pCO2ofTissGrp	Actual pCO2 of the tissue group that is served by the internal illiac arter
	whichProblem	String indicating problem to be low O2, high CO2, or both
TissDistressc	pO2ofTissGrp	Actual pO2 of the lower limb tissue group
	pCO2ofTissGrp	Actual pCO2 of the lower limb tissue
	whichProblem	Sting indicating if problem is high CO2, low O2, or both
TissDistressb	pO2ofTissGrp	The actual partial pressure of oxygen in the head, neck, spine tissue gr
	pCO2ofTissGrp	Actual pCO2 of head,neck, and spine tissue
	whichProblem	String indicating if problem is low O2, high CO2, or both
TissDistressa	pO2ofTissGrp	Actual pO2 of the upper limb tissue group
	whichProblem	String indicating if problem is high CO2, low O2, or both
	pCO2ofTissGrp	Actual pCO2 of the upper limb tissue group
TracActIS	TurnOn	The trachea irritant sensor is activated; it can now do its activity
	LevelofIrritant	The level of the irritating particulates; high, medium, or low
LaryActIS	TurnOn	The irritant sensor in the larynx is activated by the presence of aprticula
	LevelofIrritant	The level of the particulate irritants; high, medium, or low
BronActIS	TurnOn	The bronchia irritant sensor is activated
	LevelofIrritant	Level of the particulate irritant; high, medium, or low
AvelActIS	TurnOn	The sensor state is now activated.
	LevelofIrritant	The level of irritant hitting the sensor; high,medium , or low
Federate	**FromFederate**	**The string representation of th inititating federate's handle.**
Alert	**AlertSeverity**	**The string representation ofthe integral vuale of the LogType enu**
	AlertText	**The string representation of the reason ofthe alert.**
	AlertID	**The string representation of the serial number for an exception.**
ServiceLog	**ServiceName**	**The string method name of the service call generating the interacti**
	ServiceInitiator	**The string representation the initiator of the service call (FED for R**
ServiceLogArgume nts	**Handle1**	**Meaning is dependent on service invoked. parameter tis represent**
	Handle2	**Meaning is dependent on service invoked. Parameter is represent**
	HandleSet	**Meaning is dependent on service invoked. Parameter is represent**
	ObjectIDorCount	**Meaning is dependent on service invoked. Parameter is represent**
	TagOrLabelOrNam	**Meaning is dependent on service invoked. Parameter is represent**
	Time	**The string representation of the time provided to the service invok**
	Enumeration	**Meaning is dependent on service invoked. Parameter is represent**
	Boolean	**Meaning is dependent on service invoked. Parameter is represent**
ObjectInformation	**ObjectID**	**The string representation of the ObjectID that this interaction id re**
	LockedAttributes	**The string representation of the attributes that are owned by a fed**

Class/Interaction	Term	Definition
	RegisteredClass	The string representation ofthe class that was registered by the re
	RepresentedClass	The string representation of the class that was discovered by the f
PublishingClass	ObjectClass	The string representation ofthe object class and attributes publish
	InteractionClass	The string representation of the interaction class handle. The for
SubscribingClass	ObjectClass	The string representation of the object class and dattributes publis
	InteractionClass	The string representation of the interaction class handle. The for
Action	ToFederate	The string representation of the federate's handle that the interacti
SetTiming	FedReportPeriod	The string representation of the integer that is the number of seco
	TimeReportPeriod	The string representation of the integer that is the number of seco
	ObjectReportPerio	The string representation ofthe integer that is the number of secon
RequestObjectInfor	ObjectID	The string representation of the ObjectID that information is being
ModifyAttributeStat	ObjectID	The string representation of the object whose attribute token statu
e	AttributeID	The string representation of the attribute whose instance's tolekn
	TokenState	The string representation of the integral value of the RTI::TokenSt
DoResignFederatio	ResignAction	The string representation of the integral value of the TI::ResignAct
DoDeleteObject	ObjectID	The string representation of the object ID to use as an argument to
	Time	The string representation of the federation to use as an argument t
	Tag	The string to use as an argument to the deleteObject service.
DoSetLookahead	Lookahead	The string representation of a double that is the value the federate'
DoSetTimeConstrai	State	The string representation of the an integer (Ture=0, False=1) that t
Control	SetServiceLogging	The string representation of the boolean value that enables/disable
	SetLogFile	The string representation of set log file.
	DeleteObject	The string representation of delete object.
	DequeueFIFO	The string representation of the DequeueFIFO.

Appendix B

Class1	Class2
airMixture (PS)	
smokeGasMixture	
localParticleClusterCloud	
localChemicalVaporCloud	
gas	O2
	CO2
	CO
volatileChemicalVaporCloud (	
particleClusterCloud (PS)	
MedicalDrugs	Methacholine
	Albuterol
Manager	**Federate**
	Federation

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
AdminMetha		Methacholine	None	None
AdminAlbut		Albuterol	None	None
SmokeStreamStim		smokeGasMixture	None	None
VaporCloudStim		localChemicalVaporCloud	None	None
MonoxideStim		CO	None	None
ParticleCloudStim		localParticleClusterCloud	None	None
Manager.Federate	**Alert**	**Federate**	**None**	**Federate**
	ObjectInformation	**Federate**	**None**	**Federate**
	PublishingClass	**Federate**	**None**	**Federate**

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
None	Dosage	IR
	TargetSystem	
	ImmediacyofEffect	
	PotLeveloflnjury	
	IdentityProfile	
None	ImmediacyofEffect	IR
	PotLeveloflnjury	
	TargetSystem	
	IdentityProfile	
	Dosage	
None	Duration	IR
	perCO2	
	perO2	
	perCO	
	IdentityProfile	
	PotLeveloflnjury	
	perOtherInert	
	TargetSystem	
	ImmediacyofEffect	
None	Duration	IR
	Concentration	
	ImmediacyofEffect	
	TargetSystem	
	PotLeveloflnjury	
	IdentityProfile	
None	Amount	IR
	Duration	
	ImmediacyofEffect	
	IdentityProfile	
	PotLeveloflnjury	
	TargetSystem	
None	SizeOfParticles	IR
	Duration	
	ImmediacyofEffect	
	PotLeveloflnjury	
	IdentityProfile	
	TargetSystem	
None	**AlertSeverity**	IR
	AlertText	
	AlertID	
None	**ObjectID**	IR
	LockedAttributes	
	RegisteredClass	
	RepresentedClass	
None	**ObjectClass**	IR

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
	SubscribingClass	Federate	None	Federate
Manager.Federate.ServiceLog	ServiceLogArguments	Federate	None	Federate
Manager.Federate.Action	RequestPublicatio	Federate	None	Federate
	RequestSubscripti	Federate	None	Federate
	SetTiming	Federate	None	Federate
	RequestObjectInfor	Federate	None	Federate
	ModifyAttributeState	Federate	None	Federate
	Control	Federate	None	Federate
Manager.Federate.Action.RemoteServiceInvocation	DoResignFederatio	Federate	None	Federate
	DoDeleteObject	Federate	None	Federate
	DoSetLookahead	Federate	None	Federate
	DoSetTimeConstra	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
	InteractionClass	
None	ObjectClass	IR
	InteractionClass	
None	Handle1	IR
	Handle2	
	HandleSet	
	ObjectIDorCount	
	TagOrLabelOrNam	
	Time	
	Enumeration	
	Boolean	
None	None	IR
None	None	IR
None	FedReportPeriod	IR
	TimeReportPeriod	
	ObjectReportPerio	
None	ObjectID	IR
None	ObjectID	IR
	AttributeID	
	TokenState	
None	SetServiceLogging	IR
	SetLogFile	
	DeleteObject	
	DequeueFIFO	
None	ResignAction	IR
None	ObjectID	IR
	Time	
	Tag	
None	Lookahead	IR
None	State	IR
None	None	IR
None	None	IR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
airMixture	perO2	float	1
	perN2	float	1
	perCO2	float	1
	altitude	float	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	LocationXY	XYCoorData	1
smokeGasMixture	perCO2	float	1
	perO2	float	1
	perCO	float	1
	perOtherInert	float	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
localParticleClusterCloud	SizeofParticles	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IndentityProfile	IdentityProfileData	1
	TargetSystem	string	1
localChemicalVaporCloud	Concentration	float	1
	IdentityProfile	IdentityProfileData	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
gas	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
volatileChemicalVaporCloud	LocationXY	XYCoorData	1
	CloudDiameter	float	1
	Concentration	float	1
	Altitude	float	1
	LocationLL	LocationLLData	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	Speed	float	1
	DirectionofMotion	XYCoorData	1
O2	AmtO2	float	1
CO2	AmtCO2	float	1
CO	AmtCO	float	1
particleClusterCloud	LocationXY	XYCoorData	1

Units	Resolution	Accuracy	Accuracy Condition
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
m	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
microns	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
microns	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
		perfect	always
mg/m^3	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
m	tenths	perfect	always
mg/m^3	tenths	perfect	always
m	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
km/sec	tenths	perfect	always
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	LocationLL	LocationLLData	1
	ParticleSizeGroups	ParticleSizeGroupList	1
	Altitude	float	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	Speed	float	1
	DirectionofMotion	XYCoorData	1
Methacholine	Dosage	double	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
Albuterol	Dosage	float	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentifyProfile	IdentityProfileData	1
	TargetSystem	string	1
	ImmediacyofEffect	ImmediacyofEffectData	1
Federate	**FederateHost**	**string**	1
	FederateHandle	**string**	1
	FederateState	**string**	1
	FederateName	**string**	1
	RTIversion	**string**	1
	TimeManagerState	**string**	1
	FederateLookahead	**string**	1
	FederateTime	**string**	1
	TimeConstrained	**string**	1
	TimeRegulating	**string**	1
	FIFOlength	**string**	1
	TSOlength	**string**	1
	DequeueFIFOasync	**string**	1
	TotalObjectCount	**string**	1
	HoldingTokensObjectCou	**string**	1
	DeletedObjectCount	**string**	1
	NumAttributes	**string**	1
	NumParameters	**string**	1
Federation	**FederationName**	**string**	1
	FederationState	**string**	1
	FederatesInFederation	**string**	1
	SaveIsScheduled	**string**	1
	ScheduledSaveTime	**string**	1
	RTIversion	**string**	1
AdminMetha	Dosage	double	1
	TargetSystem	string	1
	ImmediacyofEffect	ImmediacyofEffectData	1

Units	Resolution	Accuracy	Accuracy Condition
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
m	tenths	perfect	always
N/A	N/A	N/A	N/A
		perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
km/sec	tenths	perfect	always
N/A	N/A	N/A	N/A
gm/ml	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
gm/ml	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
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		perfect	always
		perfect	always
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		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
gm/ml	nearest integer	perfect	always
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Conditional	upon "big enough" change	N	UR
Conditional	If sizes drop out;physics alg	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional		N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
AdminAlbut	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	Dosage	double	1
SmokeStreamStim	Duration	float	1
	perCO2	float	1
	perO2	float	1
	perCO	float	1
	IdentityProfile	IdentityProfileData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	perOtherInert	float	1
	TargetSystem	string	1
	ImmediacyofEffect	ImmediacyofEffectData	1
VaporCloudStim	Duration	float	1
	Concentration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
MonoxideStim	Amount	float	1
	Duration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	IdentityProfile	IdentityProfileData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	TargetSystem	string	1
ParticleCloudStim	SizeOfParticles	float	1
	Duration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
Alert	**AlertSeverity**	**string**	**1**
	AlertText	**string**	**1**
	AlertID	**string**	**1**
ServiceLogArguments	**Handle1**	**string**	**1**
	Handle2	**string**	**1**
	HandleSet	**string**	**1**
	ObjectIDorCount	**string**	**1**
	TagOrLabelOrName	**string**	**1**
	Time	**string**	**1**
	Enumeration	**string**	**1**
	Boolean	**string**	**1**
ObjectInformation	**ObjectID**	**string**	**1**

Units	Resolution	Accuracy	Accuracy Condition
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
gm/ml	nearest integer	perfect	always
sec	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
percentage	nearest integer	perfect	always
mg/m^3	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
sec	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
microns	nearest integer	perfect	always
sec	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	LockedAttributes	string	1
	RegisteredClass	string	1
	RepresentedClass	string	1
PublishingClass	ObjectClass	string	1
	InteractionClass	string	1
SubscribingClass	ObjectClass	string	1
	InteractionClass	string	1
SetTiming	FedReportPeriod	string	1
	TimeReportPeriod	string	1
	ObjectReportPeriod	string	1
RequestObjectInformatio	ObjectID	string	1
ModifyAttributeState	ObjectID	string	1
	AttributeID	string	1
	TokenState	string	1
DoResignFederationExec	ResignAction	string	1
DoDeleteObject	ObjectID	string	1
	Time	string	1
	Tag	string	1
DoSetLookahead	Lookahead	string	1
DoSetTimeConstrained	State	string	1
Control	SetServiceLogging	string	1
	SetLogFile	string	1
	DeleteObject	string	1
	DequeueFIFO	string	1

Units	Resolution	Accuracy	Accuracy Condition
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Identifier	Enumerator	Representation
InjuryLevelData	critical	1
	serious	2
	minor	3
	none	4
	unknown	5
ImmediacyofEffectData	Immediate	1
	Seconds	2
	FewMinutes	3
	Hour	4
	FewHours	5
	SeveralHours	6
	TwelveHours	7
	Day	8
	Days	9
	Week	10
	Weeks	11
	Month	12
	LongTerm	13

Complex Datatype	Field Name	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
ParticleSizeGroupList	SmallSize	boolean	1	N/A	N/A	perfect	always
	MediumSiz	boolean	1	N/A	N/A	perfect	always
	LargeSize	boolean	1	N/A	N/A	perfect	always
LocationLLData	Latitude	LatLongCo	1	N/A	N/A	N/A	N/A
	Longitude	LatLongCo	1	N/A	N/A	N/A	N/A
LatLongCoordFormat	degrees	double	1	N/A	N/A	perfect	always
	minutes	double	1	N/A	N/A	perfect	always
XYCoorData	X	float	1	km	hundredths	perfect	always
	Y	float	1	km	hundredths	perfect	always
IdentityProfileData	BronchoDil	boolean	1	N/A	N/A	perfect	always
	Bronchioco	boolean	1	N/A	N/A	perfect	always
	AveloiInfla	boolean	1	N/A	N/A	perfect	always
	ModifyAirP	boolean	1			perfect	always
	ModifyAmb	boolean	1			perfect	always
	ModifyAmb	boolean	1			perfect	always
	BindHEM	boolean	1	N/A	N/A	perfect	always
GenericInjuryLevelInfo	Level	any	1			perfect	always
	PotentialInj	InjuryLevel	1	N/A	N/A	N/A	N/A

Class	Component
smokeGasMixture	CO
	CO2
	O2

Term	Definition
airMixture	The environmental air surrounding the body; used in more non-local and potentially ch
smokeGasMixture	The mixture of gases which are to be inhaled by the human and which form the gases
localParticleClusterCloud	A small cloud of particles nearby the body; involved in interactions; used in local repre
localChemicalVaporCloud	A small chemical vapor cloud that is nearby the body, and is used in interactions; local
gas	One of the states of matter; refers to stimuli in this state; stimuli serves to evoke body
volatileChemicalVaporClou	Vapors of volatile chemicals which affect the respiratory system. Used for more globa
O2	oxygen in the stimulus
CO2	carbon dioxide -- in the stimuli
CO	Carbon Monoxide in the stimulus
particleClusterCloud	Small particles found in smoke which serve as irritants to the human respiratory syste
MedicalDrugs	Stimuli which are drugs given in a medical context
Methacholine	A medical drug which constricts the bronchial pasages
Albuterol	A medical drug which causes dilation of the bronchial tubes
Manager	**Manager class for the management object model.**
Federate	**Manager subclass for federates specific information.**
Federation	**Manager subclass for federation specific information.**

Term	Definition
AdminMetha	Administer the medical drug methacholine
AdminAlbut	Administer the drug albuterol
SmokeStreamStim	A smoke stream that is blown right onto the body; the stimuli exists right near the body
VaporCloudStim	A toxic vapor cloud is the stimuli; exists right near the body
MonoxideStim	The stimuli of carbon monoxide in gaseous form is immanent
ParticleCloudStim	In the particle cloud stimuli, ash particles are the stimuli
Manager	The Manager interaction group contains all Management Object Model interactio
Federate	The Manager::Federate interaction group contains all MOM interactions associa
Alert	The Manager::Federate::Alert interaction allows the RTI to inform the federation
ServiceLog	The Manager::Federate::ServiceLog interaction allows detailed tracing of RTIam
ServiceLogArguments	The Manager::Federate::ServiceLog::ServiceLogArguments interaction allows d
ObjectInformation	The Manager::Federate::ObjectInformation interaction is sent by the RTI in resp
PublishingClass	The Manager::Federate::PublishingClass interaction is sent by the RTI in respon
SubscribingClass	The Manager::Federate::SubscribeClass interaction is sent by the RTI in respon
Action	The Manager::Federate::Action interaction is used to preform an action on a re
RequestPublicationTree	The Manager::Federate::RequestPublicationTree is used to request that the RTI
RequestSubscriptionTree	The Manager::Federate::RequestSubscriptionTree interaction is used to reques
SetTiming	The Manager::Federate::SetTiming interaction allows modification of a federate'
RequestObjectInformatio	The Manager::Federate::Action::RequestObjectInformation interaction causes t
ModifyAttributeState	The Manager::Federate::Action::ModifyAttributeState interaction allows federat
RemoteServiceInvocation	The Manager::Federate::Action::RemoteServiceInvocation interaction group co
DoResignFederationExec	The Manager::Federate::Action::RemoteServiceInvocation::DoResignFederation
DoDeleteObject	The Manager::Federate::Action::RemoteServiceInvocation::DoDelete interactio
DoSetLookahead	The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead in
DoSetTimeConstrained	The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead in
DoTurnRegulationOn	The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationO
DoTurnRegulationOff	The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationO
Control	The Manager::Federate::Action::Control interaction is used to set service loggin

Class/Interaction	Term	Definition
airMixture	perO2	Percent of oxygen in the environmental air
	perN2	Percent of nitrogen in the environmental air
	perCO2	Percent of carbon dioxide in the environmental air.
	altitude	The height above sea level.
	PotLeveloflnjury	The potential gravity of the injury caused by the stimuli; may involve diff
	ImmediacyofEffect	How long before the stimuli takes effect
	TargetSystem	The body system which is affected by the stimuli
	IdentityProfile	The signature of the stimuli with regard to its effects on the body
	LocationXY	The latitude and longitude of this particular air Mixture
smokeGasMixture	perCO2	Percnetage of carbon dioxide in the gas mixture of smoke
	perO2	Percentage of oxygen making up the gases in the smoke stream
	perCO	Percentage of carbon monoxide making up the gases in the smoke stre
	perOtherInert	Percentage of other inert gases forming the gas mixture of the smoke st
	IdentityProfile	Stimuli signature wrt the body
	TargetSystem	Physiological system affected by stimuli
	PotLeveloflnjury	The potential level of injury to the body -- generic -- can involve multiple
	ImmediacyofEffect	How fast acting is the stimuli
localParticleClusterCloud	SizeofParticles	Only one particle size is represented in this attribute
	ImmediacyofEffect	How fast acting is the stimuli.
	PotLeveloflnjury	Potential degree of harm due to the receipt of the stimuli by the body;
	IndentityProfile	List of characteristics of the stimuli
	TargetSystem	The physiological system upon which the stimuli has an effect.
localChemicalVaporCloud	Concentration	Strength of the chemical vapor cloud
	IdentityProfile	The characteristics of the stimuli
	ImmediacyofEffect	How quickly the stimuli has an effect.
	TargetSystem	The physiological system upon which the stimuli has an effect
	PotLeveloflnjury	Potential degree of harm which the stimuli causes the recipient body; m
gas	ImmediacyofEffect	How quickly the stimuli has an effect.
	PotLeveloflnjury	The potential degree of harm which the stimuli causes the recipient bod
	IdentityProfile	The characteristics of the stimuli
	TargetSystem	The physiological system upon which the stimuli has an effect
volatileChemicalVaporCloud	LocationXY	Physical location of the chemical vapor cloud given in xy coordinates
	CloudDiameter	Distance across the roughly spherical clooud
	Concentration	Level of chemical vapor cloud per cubic volume
	Altitude	Height above sea level of the center of the cloud
	LocationLL	The location of the toxic vapor cloud given in latitide and longitude
	ImmediacyofEffect	How quickly the stimuli has an effect.
	PotLeveloflnjury	The potential degree of harm which the stimuli has upon the recipient b
	TargetSystem	The physiological system which is the target of the stimuli activity
	IdentityProfile	Characteristics of the sti,uli
	Speed	The magnitude of the velocity with which the stimuli is moving; used in g
	DirectionofMotion	The vector representation of the direction in which the stimuli is moving
O2	AmtO2	Amount of oxygen in the stimulus; measured as a percentage of a stand
CO2	AmtCO2	Amount of carbon dioxide in the stimulus; measured as a percentage of
CO	AmtCO	Amount of carbon monoxide in the stimulus; measured as a percentage
particleClusterCloud	LocationXY	Location of the center of the particle cloud in x , coordinates
	LocationLL	Location of the center of the particle cloud in latitiude and longitude

Class/Interaction	Term	Definition
	ParticleSizeGroups	The particle size groups found in the particle cloud
	Altitude	The height above sea level of the roughly spherical particle cloud
	IdentityProfile	the characteristics of the stimuli
	TargetSystem	The physiological system which is the recipient of the sti,uli's effects
	PotLevelofInjury	Potential degree of harm that the stimuli has upon the recipient body; m
	ImmediacyofEffect	How quickly the stimuli has an effect
	Speed	The magnitude of the velocity vector of the stimuli; used in global repres
	DirectionofMotion	The vector representation of the direction in which the stimuli is moving,
Methacholine	Dosage	Amount of drug
	PotLevelofInjury	The potential level of injury information; may be mulitple levels dependin
	ImmediacyofEffect	How long it takes for the stimuli to have an effect on the recipient -- nom
	TargetSystem	The physiological system on which the stimuli could have an effect
	IdentityProfile	The identity of the stimuli vis-a-vis the recipient body
Albuterol	Dosage	Amount of drug given
	PotLevelofInjury	Potential level of injury to recipient; generic info conveyed on nominal in
	IdentityProfile	The idnetity of the stimuli vis-a-vis the recipient; i.e., generic possible eff
	TargetSystem	The physiological system which could be affected by the stimuli
	ImmediacyofEffect	Nominal information on how fast acting the stimuli could be on a recipie
Federate	**FederateHost**	**The string representation of the hostname the federate is executin**
	FederateHandle	**The string representation of an integer that is the handle assigned**
	FederateState	**The string representation of the integer corresponding to the value**
	FederateName	**The string representation of the name spefied by the federate at jo**
	RTIversion	**The string representation of the software version of the TRI library.**
	TimeManagerState	**The string representation of the integer correpsonding to the value**
	FederateLookahea	**The string representation of a double that is the value of the feder**
	FederateTime	**The string representation of a double that is the value of the federa**
	TimeConstrained	**The character representation of an integer that specifies whether t**
	TimeRegulating	**The character representation of an integer that specifies whether t**
	FIFOlength	**The string representation of an integer that specifies the number o**
	TSOlength	**The string representation of an integer that specifies the number o**
	DequeueFIFOasyn	**The string representation of the boolean value indicating whether**
	TotalObjectCount	**The string representation of an integer that specifies the total nu**
	HoldingTokensObj	**The string representation of an integer that specified the number**
	DeletedObjectCoun	**The string representation of an integer that specifies the number o**
	NumAttributes	**The string representation of an integer that acts as an indicator of**
	NumParameters	**The string representation of an integer that acts as an indicator of**
Federation	**FederationName**	**The string name of the federation.**
	FederationState	**The string representation of the integral value of the RTI::Federati**
	FederatesInFederat	**The string representation of the integral number of federates joine**
	SaveIsScheduled	**The string representation of the boolean value indicating whether**
	ScheduledSaveTim	**The string representation of the double-precision floating-point nu**
	RTIversion	**The string representation of the version number of the federation e**
AdminMetha	Dosage	Amount
	TargetSystem	Recipient physiological system of the stimuli
	ImmediacyofEffect	How fast acting the stimuli could be; generic info
	PotLevelofInjury	Potential level of injury; nominal info; could be mulitple levels depending
	IdentityProfile	The identity (behavior) of the stimuli vis -a vis the recipient body

Class/Interaction	Term	Definition
AdminAlbut	ImmediacyofEffect	How fast acting the stimuli is
	PotLevelofInjury	The nominal injury level data; may be more than one depending on amo
	TargetSystem	Physiological system affected by the stimuli
	IdentityProfile	The identity (behavior) of the stimuli vis-a-vis the recipient
	Dosage	Amount
SmokeStreamStim	Duration	Length of time the smoke stream is directly blowing at a body
	perCO2	percentage of CO2 in incoming smoke stream
	perO2	percentage of O2 in smoke mixture
	perCO	percentage of CO in smoke
	IdentityProfile	the identity profile of the smoke stream vis-a-vis the human body
	PotLevelofInjury	Potential level of injury
	perOtherInert	percentage of other inert gases in the smoke stream
	TargetSystem	Physiological system impacted by the smoke stream
	ImmediacyofEffect	How long it takes the stimuli to have an effect.
VaporCloudStim	Duration	Length of time the toxic vapor cloud is immanent
	Concentration	The concentration of the cloud in ml/cubic cm
	ImmediacyofEffect	How long it takes for the stimuli to have an effect.
	TargetSystem	The impacted physiological system
	PotLevelofInjury	The potential level of harm to the body
	IdentityProfile	Stimuli identification with respect to activity on the body
MonoxideStim	Amount	The amount of carbon monoxide that is input; measured as percentage
	Duration	Lenth of time that the stimulus is applied
	ImmediacyofEffect	How quickly the stimuli has an effect.
	IdentityProfile	The profile of the stimuli with respect to its effect on the body
	PotLevelofInjury	The potential level of injury to the body
	TargetSystem	The physiological system which is affected by the stimuli
ParticleCloudStim	SizeOfParticles	The average size of the particles in the particle cluster. Cluster particles
	Duration	Length of time the stimuli is operating
	ImmediacyofEffect	How quickly the stimuli has an effect
	PotLevelofInjury	The ptoential of harm to the body
	IdentityProfile	Who the stimuli is with respect to the body
	TargetSystem	The phsiological system affected by teh stimuli
Federate	**FromFederate**	**The string representation of th inititating federate's handle.**
Alert	**AlertSeverity**	**The string representation ofthe integral vuale of the LogType enu**
	AlertText	**The string representation of the reason ofthe alert.**
	AlertID	**The string representation of the serial number for an exception.**
ServiceLog	**ServiceName**	**The string method name of the service call generating the interacti**
	ServiceInitiator	**The string representation the initiator of the service call (FED for R**
ServiceLogArgume nts	**Handle1**	**Meaning is dependent on service invoked. parameter tis represent**
	Handle2	**Meaning is dependent on service invoked. Parameter is represent**
	HandleSet	**Meaning is dependent on service invoked. Parameter is represent**
	ObjectIDorCount	**Meaning is dependent on service invoked. Parameter is represent**
	TagOrLabelOrNam	**Meaning is dependent on service invoked. Parameter is represent**
	Time	**The string representation of the time provided to the service invok**
	Enumeration	**Meaning is dependent on service invoked. Parameter is represent**
	Boolean	**Meaning is dependent on service invoked. Parameter is represent**
ObjectInformation	**ObjectID**	**The string representation of the ObjectID that this interaction id re**

Class/Interaction	Term	Definition
	LockedAttributes	The string representation of the attributes that are owned by a fed
	RegisteredClass	The string representation ofthe class that was registered by the re
	RepresentedClass	The string representation of the class that was discovered by the f
PublishingClass	ObjectClass	The string representation ofthe object class and attributes publish
	InteractionClass	The string representation of the interaction class handle. The for
SubscribingClass	ObjectClass	The string representation of the object class and dattributes publis
	InteractionClass	The string representation of the interaction class handle. The for
Action	ToFederate	The string representation of the federate's handle that the interacti
SetTiming	FedReportPeriod	The string representation of the integer that is the number of seco
	TimeReportPeriod	The string representation of the integer that is the number of seco
	ObjectReportPerio	The string representation ofthe integer that is the number of secon
RequestObjectInfor	ObjectID	The string representation of the ObjectID that information is being
ModifyAttributeStat	ObjectID	The string representation of the object whose attribute token statu
e	AttributeID	The string representation of the attribute whose instance's tolekn
	TokenState	The string representation of the integral value of the RTI::TokenSt
DoResignFederatio	ResignAction	The string representation of the integral value of the TI::ResignAct
DoDeleteObject	ObjectID	The string representation of the object ID to use as an argument to
	Time	The string representation of the federation to use as an argument t
	Tag	The string to use as an argument to the deleteObject service.
DoSetLookahead	Lookahead	The string representation of a double that is the value the federate'
DoSetTimeConstrai	State	The string representation of the an integer (Ture=0, False=1) that t
Control	SetServiceLogging	The string representation of the boolean value that enables/disable
	SetLogFile	The string representation of set log file.
	DeleteObject	The string representation of delete object.
	DequeueFIFO	The string representation of the DequeueFIFO.

Appendix C

Version 1 FOM

Class1	Class2
airMixture (PS)	
smokeGasMixture	
localParticleClusterCloud	
localChemicalVaporCloud	
gas	O2
	CO2
	CO
volatileChemicalVaporCloud (P	
particleClusterCloud (PS)	
MedicalDrugs	Albuterol
	Methacholine
BodyEnvironMatrix (PS)	
Manager	**Federate**
	Federation

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
AdminMetha		Methacholine	None	BodyEnvironMatrix
AdminAlbut		Albuterol	None	BodyEnvironMatrix
SmokeStreamStim		smokeGasMixture	None	BodyEnvironMatrix
VaporCloudStim		localChemicalVaporCloud	None	BodyEnvironMatrix
MonoxideStim		CO	None	BodyEnvironMatrix
ParticleCloudStim		localParticleClusterCloud	None	BodyEnvironMatrix
Manager.Federate	**Alert**	**Federate**	**None**	**Federate**
	ObjectInformation	**Federate**	**None**	**Federate**
	PublishingClass	**Federate**	**None**	**Federate**
	SubscribingClass	**Federate**	**None**	**Federate**

Object/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
BodyAffectors	Dosage IdentityProfile TargetSystem ImmediacyofEffect PotLevelofInjury	IR
BodyAffectors	Dosage IdentityProfile TargetSystem ImmediacyofEffect PotLevelofInjury	IR
AirComponents Humidity	Duration perCO2 perO2 perCO IdentityProfile PotLevelofInjury perOtherInert TargetSystem ImmediacyofEffect	IR
BodyAffectors	Duration Concentration ImmediacyofEffect TargetSystem PotLevelofInjury IdentityProfile	IR
AirComponents Humidity	Amount Duration ImmediacyofEffect IdentityProfile PotLevelofInjury TargetSystem	IR
BodyAffectors	SizeOfParticles Duration ImmediacyofEffect PotLevelofInjury IdentityProfile TargetSystem	IR
None	**AlertSeverity** **AlertText** **AlertID**	**IR**
None	**ObjectID** **LockedAttributes** **RegisteredClass** **RepresentedClass**	**IR**
None	**ObjectClass** **InteractionClass**	**IR**
None	**ObjectClass** **InteractionClass**	**IR**

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
Manager.Federate.ServiceLog	ServiceLogArguments	Federate	None	Federate
Manager.Federate.Action	RequestPublication	Federate	None	Federate
	RequestSubscripti	Federate	None	Federate
	SetTiming	Federate	None	Federate
	RequestObjectInfor	Federate	None	Federate
	ModifyAttributeState	Federate	None	Federate
	Control	Federate	None	Federate
Manager.Federate.Action.RemoteServiceInvocation	DoResignFederatio	Federate	None	Federate
	DoDeleteObject	Federate	None	Federate
	DoSetLookahead	Federate	None	Federate
	DoSetTimeConstrai	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate

Object/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
None	Handle1	IR
	Handle2	
	HandleSet	
	ObjectIDorCount	
	TagOrLabelOrNam	
	Time	
	Enumeration	
	Boolean	
None	None	IR
None	None	IR
None	FedReportPeriod	IR
	TimeReportPeriod	
	ObjectReportPerio	
None	ObjectID	IR
None	ObjectID	IR
	AttributeID	
	TokenState	
None	SetServiceLogging	IR
	SetLogFile	
	DeleteObject	
	DequeueFIFO	
None	ResignAction	IR
None	ObjectID	IR
	Time	
	Tag	
None	Lookahead	IR
None	State	IR
None	None	IR
None	None	IR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
airMixture	perO2	float	1
	perN2	float	1
	perCO2	float	1
	altitude	float	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	LocationXY	XYCoorData	1
smokeGasMixture	perCO2	long	1
	perO2	float	1
	perCO	float	1
	perOtherInert	float	1
	IndentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
localParticleClusterCloud	SizeofParticles	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IndentityProfile	IdentityProfileData	1
	TargetSystem	string	1
localChemicalVaporCloud	Concentration	float	1
	IdentityProfile	IdentityProfileData	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
gas	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
volatileChemicalVaporCloud	LocationXY	XYCoorData	1
	CloudDiameter	float	1
	Concentration	float	1
	Altitude	float	1
	LocationLL	LocationLLData	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	Speed	float	1
	DirectionofMotion	XYCoorData	1
O2	AmtO2	float	1
CO2	AmtCO2	float	1
CO	AmtCO	float	1
particleClusterCloud	LocationXY	XYCoorData	1
	LocationLL	LocationLLData	1
	ParticleSizeGroups	ParticleSizeGroupList	1
	Altitude	float	1
	IdentityProfile	IdentityProfileData	1

Units	Resolution	Accuracy	Accuracy Condition
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
m	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
microns	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
microns	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
		perfect	always
mg/m^3	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
m	tenths	perfect	always
mg/m^3	tenths	perfect	always
m	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
km/sec	tenths	perfect	always
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
m	tenths	perfect	always
N/A	N/A	N/A	N/A

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	If sizes drop out;physics algo	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	Speed	float	1
	DirectionofMotion	XYCoorData	1
BodyEnvironMatrix	ExternalTemp	float	1
	AirPressure	float	1
	Altitude	float	1
	LocationData	XYCoorData	1
	Humidity	float	1
	AirComponents	AirComponentData	1
	BodyAffectors	string	1+
Albuterol	Dosage	double	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
Methacholine	Dosage	double	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
Federate	**FederateHost**	**string**	**1**
	FederateHandle	**string**	**1**
	FederateState	**string**	**1**
	FederateName	**string**	**1**
	RTIversion	**string**	**1**
	TimeManagerState	**string**	**1**
	FederateLookahead	**string**	**1**
	FederateTime	**string**	**1**
	TimeConstrained	**string**	**1**
	TimeRegulating	**string**	**1**
	FIFOlength	**string**	**1**
	TSOlength	**string**	**1**
	DequeueFIFOasync	**string**	**1**
	TotalObjectCount	**string**	**1**
	HoldingTokensObjectCou	**string**	**1**
	DeletedObjectCount	**string**	**1**
	NumAttributes	**string**	**1**
	NumParameters	**string**	**1**
Federation	**FederationName**	**string**	**1**
	FederationState	**string**	**1**
	FederatesInFederation	**string**	**1**
	SaveIsScheduled	**string**	**1**
	ScheduledSaveTime	**string**	**1**
	RTIversion	**string**	**1**
AdminMetha	Dosage	double	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	ImmediacyofEffect	ImmediacyofEffectData	1

Units	Resolution	Accuracy	Accuracy Condition
		perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
km/sec	tenths	perfect	always
N/A	N/A	N/A	N/A
degrees Farenheit	tenths	perfect	always
mm Hg	tenths	perfect	always
m	nearest integer	perfect	always
N/A	N/A	N/A	N/A
		perfect	always
N/A	N/A	N/A	N/A
		perfect	always
gm/ml	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
gm/ml	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
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		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
gm/ml	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Static		N	UR
Static		N	UR
Static		N	UR
Conditional		N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Static		N	UR
Static		N	UR
Conditional		N	UR
Conditional		N	UR
Static		N	UR
Conditional		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
Conditional		**N**	**UR**
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	PotLevelofInjury	GenericInjuryLevelInfo	1+
AdminAlbut	Dosage	double	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
SmokeStreamStim	Duration	float	1
	perCO2	float	1
	perO2	float	1
	perCO	float	1
	IdentityProfile	IdentityProfileData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	perOtherInert	float	1
	TargetSystem	string	1
	ImmediacyofEffect	ImmediacyofEffectData	1
VaporCloudStim	Duration	float	1
	Concentration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	IdentityProfile	IdentityProfileData	1
MonoxideStim	Amount	float	1
	Duration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	IdentityProfile	IdentityProfileData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	TargetSystem	string	1
ParticleCloudStim	SizeOfParticles	float	1
	Duration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
Alert	**AlertSeverity**	**string**	**1**
	AlertText	**string**	**1**
	AlertID	**string**	**1**
ServiceLogArguments	**Handle1**	**string**	**1**
	Handle2	**string**	**1**
	HandleSet	**string**	**1**
	ObjectIDorCount	**string**	**1**
	TagOrLabelOrName	**string**	**1**
	Time	**string**	**1**
	Enumeration	**string**	**1**
	Boolean	**string**	**1**
ObjectInformation	**ObjectID**	**string**	**1**
	LockedAttributes	**string**	**1**
	RegisteredClass	**string**	**1**
	RepresentedClass	**string**	**1**
PublishingClass	**ObjectClass**	**string**	**1**
	InteractionClass	**string**	**1**

Units	Resolution	Accuracy	Accuracy Condition
N/A	N/A	N/A	N/A
gm/ml	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
sec	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
percentage	nearest integer	perfect	always
mg/m^3	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
sec	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
microns	nearest integer	perfect	always
sec	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
SubscribingClass	ObjectClass	string	1
	InteractionClass	string	1
SetTiming	FedReportPeriod	string	1
	TimeReportPeriod	string	1
	ObjectReportPeriod	string	1
RequestObjectInformation	ObjectID	string	1
ModifyAttributeState	ObjectID	string	1
	AttributeID	string	1
	TokenState	string	1
DoResignFederationExec	ResignAction	string	1
DoDeleteObject	ObjectID	string	1
	Time	string	1
	Tag	string	1
DoSetLookahead	Lookahead	string	1
DoSetTimeConstrained	State	string	1
Control	SetServiceLogging	string	1
	SetLogFile	string	1
	DeleteObject	string	1
	DequeueFIFO	string	1

Units	Resolution	Accuracy	Accuracy Condition
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Identifier	Enumerator	Representation
InjuryLevelData	critical	1
	serious	2
	minor	3
	none	4
	unknown	5
ImmediacyofEffectData	Immediate	1
	Seconds	2
	FewMinutes	3
	Hour	4
	FewHours	5
	SeveralHours	6
	TwelveHours	7
	Day	8
	Days	9
	Week	10
	Weeks	11
	Month	12
	LongTerm	13

Complex Datatype	Field Name	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
ParticleSize GroupList	SmallSize	boolean	1	N/A	N/A	perfect	always
	MediumSiz	boolean	1	N/A	N/A	perfect	always
	LargeSize	boolean	1	N/A	N/A	perfect	always
LocationLL Data	Latitude	LatLongCo	1	N/A	N/A	N/A	N/A
	Longitude	LatLongCo	1	N/A	N/A	N/A	N/A
LatLongCo ordFormat	degrees	double	1	N/A	N/A	perfect	always
	minutes	double	1	N/A	N/A	perfect	always
XYCoorDat a	X	float	1	km	hundredths	perfect	always
	Y	float	1	km	hundredths	perfect	always
IdentityProfi leData	Bronchioco	boolean	1	N/A	N/A	perfect	always
	AveioiInfla	boolean	1	N/A	N/A	perfect	always
	ModifyAirPr	boolean	1			perfect	always
	ModifyAmbi	boolean	1			perfect	always
	ModifyAmbi	boolean	1			perfect	always
	BindHEM	boolean	1	N/A	N/A	perfect	always
	Bronchiodil	boolean	1	N/A	N/A	perfect	always
GenericInju ryLevelInfo	Level	any	1			perfect	always
	PotentialInju	InjuryLevel	1	N/A	N/A	N/A	N/A
AirCompon entData	COper	float	1	percentage	tenths	perfect	always
	Argonper	float	1	percentage	tenths	perfect	always
	O2per	float	1	percentage	tenths	perfect	always
	CO2per	float	1	percentage	tenths	perfect	always
	N2per	float	1	percentage	tenths	perfect	always

Term	Definition
airMixture	The environmental air surrounding the body; used in more non-local and potentially chang
smokeGasMixture	The mixture of gases which are to be inhaled by the human and which form the gases in
localParticleClusterCloud	A small cloud of particles nearby the body; involved in interactions; used in local represen
localChemicalVaporCloud	A small chemical vapor cloud that is nearby the body, and is used in interactions; local rep
gas	One of the states of matter; refers to stimuli in this state; stimuli serves to evoke body res
volatileChemicalVaporCloud	Vapors of volatile chemicals which affect the respiratory system. Used for more global sit
O2	oxygen in the stimulus
CO2	carbon dioxide -- in the stimuli
CO	Carbon Monoxide in the stimulus
particleClusterCloud	Small particles found in smoke which serve as irritants to the human respiratory system; u
MedicalDrugs	Stimuli which are drugs given in a medical context.
BodyEnvironMatrix	This is the body interface interested in the environmental inputs
Albuterol	A medical drug which causes dilation of the bronchial tubes.
Methacholine	A medical drug which constricts the bronchial passages.
Manager	**Manager class for the management object model.**
Federate	**Manager subclass for federates specific information.**
Federation	**Manager subclass for federation specific information.**

Term	Definition
AdminMetha	Administer the medical drug mathacholine
AdminAlbut	Adminster the medical drug albuterol
SmokeStreamStim	A smoke stream that is blown right onto the body; the stimuli exists right near the body
VaporCloudStim	A toxic vapor cloud is the stimuli; exists right near the body
MonoxideStim	The stimuli of carbon monoxide in gaseous form is immanent
ParticleCloudStim	In the particle cloud stimuli, ash particles are the stimuli
Manager	**The Manager interaction group contains all Management Object Model interactio**
Federate	**The Manager::Federate interaction group contains all MOM interactions associat**
Alert	**The Manager::Federate::Alert interaction allows the RTI to inform the federation**
ServiceLog	**The Manager::Federate::ServiceLog interaction allows detailed tracing of RTIamb**
ServiceLogArguments	**The Manager::Federate::ServiceLog::ServiceLogArguments interaction allows de**
ObjectInformation	**The Manager::Federate::ObjectInformation interaction is sent by the RTI in respo**
PublishingClass	**The Manager::Federate::PublishingClass interaction is sent by the RTI in respons**
SubscribingClass	**The Manager::Federate::SubscribeClass interaction is sent by the RTI in respons**
Action	**The Manager::Federate::Action interaction is used to preform an action on a rem**
RequestPublicationTree	**The Manager::Federate::RequestPublicationTree is used to request that the RTI p**
RequestSubscriptionTree	**The Manager::Federate::RequestSubscriptionTree interaction is used to request**
SetTiming	**The Manager::Federate::SetTiming interaction allows modification of a federate's**
RequestObjectInformation	**The Manager::Federate::Action::RequestObjectInformation interaction causes th**
ModifyAttributeState	**The Manager::Federate::Action::ModifyAttributeState interaction allows federate**
RemoteServiceInvocation	**The Manager::Federate::Action::RemoteServiceInvocation interaction group cont**
DoResignFederationExec	**The Manager::Federate::Action::RemoteServiceInvocation::DoResignFederation**
DoDeleteObject	**The Manager::Federate::Action::RemoteServiceInvocation::DoDelete interaction**
DoSetLookahead	**The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead int**
DoSetTimeConstrained	**The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead int**
DoTurnRegulationOn	**The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationOn**
DoTurnRegulationOff	**The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationOff**
Control	**The Manager::Federate::Action::Control interaction is used to set service logging**

Class/Interaction	Term	Definition
airMixture	perO2	Percent of oxygen in the environmental air
	perN2	Percent of nitrogen in the environmental air
	perCO2	Percent of carbon dioxide in the environmental air.
	altitude	The height above sea level.
	PotLevelofInjury	The potential gravity of the injury caused by the stimuli; may involve differe
	ImmediacyofEffect	How long before the stimuli takes effect
	TargetSystem	The body system which is affected by the stimuli
	IdentityProfile	The signature of the stimuli with regard to its effects on the body
	LocationXY	The latitude and longitude of this particular air Mixture
smokeGasMixture	perCO2	Percnetage of carbon dioxide in the gas mixture of smoke
	perO2	Percentage of oxygen making up the gases in the smoke stream
	perCO	Percentage of carbon monoxide making up the gases in the smoke stream
	perOtherInert	Percentage of other inert gases forming the gas mixture of the smoke strea
	IndentityProfile	Stimuli signature wrt the body
	TargetSystem	Physiological system affected by stimuli
	PotLevelofInjury	The potential level of injury to the body -- generic -- can involve multiple lev
	ImmediacyofEffect	How fast acting is the stimuli
localParticleClusterCl oud	SizeofParticles	Only one particle size is represented in this attribute
	ImmediacyofEffect	How fast acting is the stimuli.
	PotLevelofInjury	Potential degree of harm due to the receipt of the stimuli by the body; may
	IndentityProfile	List of characteristics of the stimuli
	TargetSystem	The physiological system upon which the stimuli has an effect.
localChemicalVaporC loud	Concentration	Strength of the chemical vapor cloud
	IdentityProfile	The characteristics of the stimuli
	ImmediacyofEffect	How quickly the stimuli has an effect.
	TargetSystem	The physiological system upon which the stimuli has an effect
	PotLevelofInjury	Potential degree of harm which the stimuli causes the recipient body; may
gas	ImmediacyofEffect	How quickly the stimuli has an effect.
	PotLevelofInjury	The potential degree of harm which the stimuli causes the recipient body;
	IdentityProfile	The characteristics of the stimuli
	TargetSystem	The physiological system upon which the stimuli has an effect
volatileChemicalVapo rCloud	LocationXY	Physical location of the chemical vapor cloud given in xy coordinates
	CloudDiameter	Distance across the roughly spherical clooud
	Concentration	Level of chemical vapor cloud per cubic volume
	Altitude	Height above sea level of the center of the cloud
	LocationLL	The location of the toxic vapor cloud given in latitide and longitude
	ImmediacyofEffect	How quickly the stimuli has an effect.
	PotLevelofInjury	The potential degree of harm which the stimuli has upon the recipient body
	TargetSystem	The physiological system which is the target of the stimuli activity
	IdentityProfile	Characteristics of the sti,uli
	Speed	The magnitude of the velocity with which the stimuli is moving; used in glob
	DirectionofMotion	The vector representation of the direction in which the stimuli is moving , re
O2	AmtO2	Amount of oxygen in the stimulus; measured as a percentage of a standar
CO2	AmtCO2	Amount of carbon dioxide in the stimulus; measured as a percentage of a s
CO	AmtCO	Amount of carbon monoxide in the stimulus; measured as a percentage of
particleClusterCloud	LocationXY	Location of the center of the particle cloud in x , coordinates
	LocationLL	Location of the center of the particle cloud in latitiude and longitude
	ParticleSizeGroups	The particle size groups found in the particle cloud
	Altitude	The height above sea level of the roughly spherical particle cloud
	IdentityProfile	the characteristics of the stimuli

Class/Interaction	Term	Definition
	TargetSystem	The physiological system which is the recipient of the sti,uli's effects
	PotLevelofInjury	Potential degree of harm that the stimuli has upon the recipient body; may
	ImmediacyofEffect	How quickly the stimuli has an effect
	Speed	The magnitude of the velocity vector of the stimuli; used in global represent
	DirectionofMotion	The vector representation of the direction in which the stimuli is moving, ref
BodyEnvironMatrix	ExternalTemp	The temperature in the environment
	AirPressure	The pressure of the environment "air"
	Altitude	The height above sea level
	LocationData	Information specifiying the location of the physical body, measured from so
	Humidity	The amount of moisture in the air
	AirComponents	Composition by percentage of the gases in the environmental "air"
	BodyAffectors	A generic attribute whose cardinality is unlimited and which is used to interf
Albuterol	Dosage	Amount of drug
	PotLevelofInjury	Potential level of injury to recipient; nominal levels, could be more than on
	ImmediacyofEffect	How long before the stimuli takes effect
	TargetSystem	The system which is the recipient of the stimuli
	IdentityProfile	The identity of the stimuli vis-a-vis teh recipient; generic possible effects
Methacholine	Dosage	Amount
	ImmediacyofEffect	How long before the stimuli takes effect
	IdentityProfile	Identity of the stimuli vis-a-vis the recipient
	TargetSystem	The recipient system of the stimuli in the body
	PotLevelofInjury	Generic level of harm; may be mulitple levels ; varying with amount, etc.
Federate	**FederateHost**	**The string representation of the hostname the federate is executing**
	FederateHandle	**The string representation of an integer that is the handle assigned t**
	FederateState	**The string representation of the integer corresponding to the value**
	FederateName	**The string representation of the name speified by the federate at joi**
	RTIversion	**The string representation of the software version of the TRI library.**
	TimeManagerState	**The string representation of the integer correpsonding to the valuo**
	FederateLookahea	**The string representation of a double that is the value of the federat**
	FederateTime	**The string representation of a double that is the value of the federat**
	TimeConstrained	**The character representation of an integer that specifies whether th**
	TimeRegulating	**The character representation of an integer that specifies whether th**
	FIFOlength	**The string representation of an integer that specifies the number of**
	TSOlength	**The string representation of an integer that specifies the number of**
	DequeueFIFOasync	**The string representation of the boolean value indicating whether or**
	TotalObjectCount	**The string representation of an integer that specifies the total numb**
	HoldingTokensObj	**The string representation of an integer that specified the number of**
	DeletedObjectCoun	**The string representation of an integer that specifies the number ob**
	NumAttributes	**The string representation of an integer that acts as an indicator of t**
	NumParameters	**The string representation of an integer that acts as an indicator of t**
Federation	**FederationName**	**The string name of the federation.**
	FederationState	**The string representation of the integral value of the RTI::Federatio**
	FederatesInFederat	**The string representation of the integral number of federates joined**
	SaveIsScheduled	**The string representation of the boolean value indicating whether or**
	ScheduledSaveTim	**The string representation of the double-precision floating-point nu**
	RTIversion	**The string representation of the version number of the federation ex**
AdminMetha	Dosage	Amount
	IdentityProfile	The identity of teh stimuli vis-a-vis the recipient body
	TargetSystem	The recipient system in the body
	ImmediacyofEffect	How fast acting the stimuli is

Class/Interaction	Term	Definition
	PotLevelofInjury	Potential level of harm; may be multiple levels depending upon the amount
AdminAlbut	Dosage	Amount
	IdentityProfile	The identity of the stimuli vis-a-vis the recipient body
	TargetSystem	The recipeint system in the body
	ImmediacyofEffect	How fast acting the stimuli is
	PotLevelofInjury	The potential level of harm the stimuli could have on the body; may be muli
SmokeStreamStim	Duration	Length of time the smoke stream is directly blowing at a body
	perCO2	percentage of CO2 in incoming smoke stream
	perO2	percentage of O2 in smoke mixture
	perCO	percentage of CO in smoke
	IdentityProfile	the identity profile of the smoke stream vis-a-vis the human body
	PotLevelofInjury	Potential level of injury
	perOtherInert	percentage of other inert gases in the smoke stream
	TargetSystem	Physiological system impacted by the smoke stream
	ImmediacyofEffect	How long it takes the stimuli to have an effect.
VaporCloudStim	Duration	Length of time the toxic vapor cloud is immanent
	Concentration	The concentration of the cloud in ml/cubic cm
	ImmediacyofEffect	How long it takes for the stimuli to have an effect.
	TargetSystem	The impacted physiological system
	PotLevelofInjury	The potential level of harm to the body
	IdentityProfile	Stimuli identification with respect to activity on the body
MonoxideStim	Amount	The amount of carbon monoxide that is input; measured as percentage C
	Duration	Lenth of time that the stimulus is applied
	ImmediacyofEffect	How quickly the stimuli has an effect.
	IdentityProfile	The profile of the stimuli with respect to its effect on the body
	PotLevelofInjury	The potential level of injury to the body
	TargetSystem	The physiological system which is affected by the stimuli
ParticleCloudStim	SizeOfParticles	The average size of the particles in the particle cluster. Cluster particles as
	Duration	Length of time the stimuli is operating
	ImmediacyofEffect	How quickly the stimuli has an effect
	PotLevelofInjury	The ptoential of harm to the body
	IdentityProfile	Who the stimuli is with respect to the body
	TargetSystem	The phsiological system affected by teh stimuli
Federate	**FromFederate**	**The string representation of th inititating federate's handle.**
Alert	**AlertSeverity**	**The string representation ofthe integral vuale of the LogType enum**
	AlertText	**The string representation of the reason ofthe alert.**
	AlertID	**The string representation of the serial number for an exception.**
ServiceLog	**ServiceName**	**The string method name of the service call generating the interactio**
	ServiceInitiator	**The string representation the initiator of the service call (FED for RT**
ServiceLogArgume nts	**Handle1**	**Meaning is dependent on service invoked. parameter tis represent**
	Handle2	**Meaning is dependent on service invoked. Parameter is represente**
	HandleSet	**Meaning is dependent on service invoked. Parameter is represente**
	ObjectIDorCount	**Meaning is dependent on service invoked. Parameter is represente**
	TagOrLabelOrNam	**Meaning is dependent on service invoked. Parameter is represente**
	Time	**The string representation of the time provided to the service invoke**
	Enumeration	**Meaning is dependent on service invoked. Parameter is represente**
	Boolean	**Meaning is dependent on service invoked. Parameter is represente**
ObjectInformation	**ObjectID**	**The string representation of the ObjectID that this interaction id rep**
	LockedAttributes	**The string representation of the attributes that are owned by a feder**
	RegisteredClass	**The string representation ofthe class that was registered by the regi**

Class/Interaction	Term	Definition
	RepresentedClass	The string representation of the class that was discovered by the fr
PublishingClass	ObjectClass	The string representation ofthe object class and attributes publishe
	InteractionClass	The string representation of the interaction class handle. The forma
SubscribingClass	ObjectClass	The string representation of the object class and dattributes publis
	InteractionClass	The string representation of the interaction class handle. The forma
Action	ToFederate	The string representation of the federate's handle that the interactio
SetTiming	FedReportPeriod	The string representation of the integer that is the number of secon
	TimeReportPeriod	The string representation of the integer that is the number of secon
	ObjectReportPerio	The string representation ofthe integer that is the number of second
RequestObjectInfor	ObjectID	The string representation of the ObjectID that information is being r
ModifyAttributeStat	ObjectID	The string representation of the object whose attribute token status
e	AttributeID	The string representation of the attribute whose instance's tolekn st
	TokenState	The string representation of the integral value of the RTI::TokenStat
DoResignFederatio	ResignAction	The string representation of the integral value of the TI::ResignActio
DoDeleteObject	ObjectID	The string representation of the object ID to use as an argument to t
	Time	The string representation of the federation to use as an argument to
	Tag	The string to use as an argument to the deleteObject service.
DoSetLookahead	Lookahead	The string representation of a double that is the value the federate's
DoSetTimeConstrai	State	The string representation of the an integer (Ture=0, False=1) that to
Control	SetServiceLogging	The string representation of the boolean value that enables/disables
	SetLogFile	The string representation of set log file.
	DeleteObject	The string representation of delete object.
	DequeueFIFO	The string representation of the DequeueFIFO.

Class	Component
smokeGasMixture	CO
	CO2
	O2

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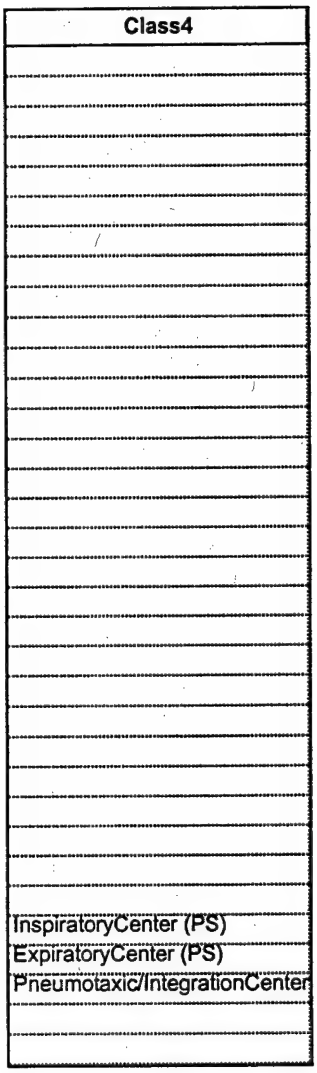
Class1	Class2	Class3
OrganicDuctwork	NervousDuctwork	SympAbdomViscNV (PS)
		SympEsophgNV (PS)
		SympCarotidNV (PS)
		SympSubclavianNV (PS)
		SympIntIlliacNV (PS)
		SympExtIlliacNV (PS)
		SympRenalNV (PS)
		SympBronchialNV (PS)
		SympatheticCardiacNerve (PS
		AbdominalNV (PS)
		IntercostalNV (PS)
		GlossopharyngealNV (PS)
		PhrenicNV (PS)
		VagusNV (PS)
		SpinalColumn (PS)
	RespiratoryDuctwork	Pharynx (PS)
		Larynx (PS)
		Trachea (PS)
		Bronchia (PS)
	CardiovascularDuctwork	ArteryinBody
		Aorta

Class4
ExternalIlliacArtR (PS)
ExternalIlliacArtL (PS)
InternalIlliacArtR (PS)
InternalIlliacArtL (PS)
IlliacArtR (PS)
IlliacArtL (PS)
AbdomParietArtL (PS)
AbdomParietArtR (PS)
AbdomViscArtL (PS)
AbdomViscArtR (PS)
RenalArt (PS)
EsophagealArt (PS)
IntercostalArt (PS)
BronchialArt (PS)
SuperiorPhrenicArt (PS)
SubclavianArtL (PS)
CommonCarotidArtL (PS)
SubclavianArtR (PS)
CommonCarotidArtR (PS)
BrachiocephalicArt (PS)
CoronaryArteryR (PS)
CoronaryArteryL (PS)
PulmonaryArteryR (PS)
PulmonaryArteryL (PS)
PulmonaryTrunk (PS)
DescendingAorta (PS)
AscendingAorta (PS)
AorticArch (PS)

Class1	Class2	Class3
		VeininBody
Organs	Heart (PS)	
	Lungs (PS)	
OrganicRCPTRS	ChemoReceptor	CO2Sensor
		PHSensor
		O2Sensor
	BaroReceptor	BAROAorticArch (PS)
		BAROCarotidSinus (PS)
	IrritantSensor	AveolarIrritantSensor (PS)
		BronchioleIrritantSensor (PS)
		LarynxIrritantSensor (PS)
		TrachealIrritantSensor (PS)
TissueGroups	UpperLimbTissue (PS)	
	HeadNeckSpineTissue (PS)	
	LowerLimbTissue (PS)	
	IntIlliacViscNParietTissue (PS)	
	AbdomViscera Tissue (PS)	
	KidneyTissue (PS)	
	HeartTissue (PS)	
	EsophagusTissue (PS)	
	LungTissue (PS)	
	RespiratoryMuscles	Abdominal (PS)
		ExternalIntercostals (PS)
		InternalIntercostals (PS)
		Diaphragm (PS)
Cavities	NasalCavity (PS)	
	ThoracicCavity (PS)	

Class4
InternalIliacVeinR (PS)
InternalIliacVeinL (PS)
ExternalIliacVeinR (PS)
ExternalIliacVeinL (PS)
SuperiorVenaCava (PS)
InferiorVenaCava (PS)
RenalVein (PS)
PhrenicVein (PS)
HepaticPortalVein (PS)
AzygosVein (PS)
BrachiocephalicVeinR (PS)
BrachiocephalicVeinL (PS)
SubclavianVeinR (PS)
SubclavianVeinL (PS)
JugularVeinsR (PS)
JugularVeinsL (PS)
PulmonaryVeinsR (PS)
PulmonaryVeinsL (PS)
CoronaryVeinR (PS)
CoronaryVeinL (PS)
MedulCO2Recpt (PS)
MedulPHRecpt (PS)
CarotO2Recpt (PS)
AorticO2Recpt (PS)

Class1	Class2	Class3
	PleuralCavity (PS)	
Chambers	HeartChambers	VentricleLeft (PS)
		VentricleRight (PS)
		AtriaLeft (PS)
		AtriaRight (PS)
Valves	HeartValves	AorticSemiLunarValve (PS)
		PulmonarySemiLunarValve (P
		MitralValve (PS)
		TricuspidValve (PS)
Epiglottis (PS)		
LumpedZones	LungConductingZone (PS)	
	LungRespiratoryZone (PS)	
Human (PS)		
CardiovascularSystem (S)		
RespiratorySystem (S)		
BodyEnvironMatrix (PS)		
airMixture (PS)		
smokeGasMixture		
localParticleClusterCloud		
localChemicalVaporCloud		
gas	O2	
	CO2	
	CO	
volatileChemicalVaporCloud (		
particleClusterCloud (PS)		
MedicalDrugs	Methacholine	
	Albuterol	
MedullRecvSendComp (S)	MedullaRegulatoryCenter	MedullaVasomotorReg (PS)
		MedullaCardioReg (PS)
		MedullaRespirReg
Manager	**Federate**	
	Federation	


Class4
InspiratoryCenter (PS)
ExpiratoryCenter (PS)
Pneumotaxic/IntegrationCenter

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
StartExpiratory		InspiratoryCenter	activityState	ExpiratoryCenter
			status	
CeaseInhale		Epiglottis	None	InspiratoryCenter
InflationMaximum		Lungs	LungVolume	Pneumotaxic/Integra
ChangeCycleTime		Pneumotaxic/Integra tionCenter	None	ExpiratoryCenter
				InspiratoryCenter
OpenEpiglottis		Pneumotaxic/Integra	None	Epiglottis
		ExpiratoryCenter		
CloseEpiglottis		Pneumotaxic/Integra	None	Epiglottis
ConstrictBronchioles		BronchioleIrritantSen	None	Bronchia
IrritantSensed	AveolarIrritantSense	AveolarIrritantSenso	None	Pneumotaxic/Integra
	BronchioleIrritantSen	BronchioleIrritantSen	None	Pneumotaxic/Integra
	LarynxIrritantSensed	LarynxIrritantSensor	None	Pneumotaxic/Integra
	TrachealIrritantSens	TrachealIrritantSens	None	Pneumotaxic/Integra
IrrSensorActivated	TracActIS	BodyEnvironMatrix	None	TrachealIrritantSens or
	LaryActIS	BodyEnvironMatrix	None	LarynxIrritantSensor
	BronActIS	BodyEnvironMatrix	None	BronchioleIrritantSen sor
	AvelActIS	BodyEnvironMatrix	None	AveolarIrritantSenso r
ChangeArteryDiame terCommand	DilateArtery	MedullaVasomotorR eg	None	AbdomParietArtL
				AbdomParietArtR
				AbdomViscArtL
				AbdomViscArtR
				RenalArt
				CommonCarotidArtL
				IlliacArtL
				BronchialArt
				EsophagealArt
				ExternalIlliacArtL
				SuperiorPhrenicArt
				BrachiocephalicArt
				CommonCarotidArtR
				ExternalIlliacArtR
				CoronaryArteryL
				CoronaryArteryR
				IntercostalArt
				SubclavianArtR
				SubclavianArtL
				PulmonaryArteryL
				PulmonaryArteryR
				IlliacArtR
				InternalIlliacArtL

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
status activityState	None	IR
activityState	None	IR
None	None	IR
CycleTime	Direction	IR
CycleTime	CycleChange	
status	None	IR
status	None	IR
Diameter	Amount	IR
None	Location	IR
None	Location	IR
None	Location	IR
None	Location	IR
Status	TurnOn LevelofIrritant	IR
Status	TurnOn LevelofIrritant	IR
Status	TurnOn LevelofIrritant	IR
Status	TurnOn LevelofIrritant	IR
Diameter	Amount	IR

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
				InternalIliacArtR
	ConstrictArtery	MedullaVasomotorReg	None	AbdomParietArtR
				AbdomParietArtL
				AbdomViscArtL
				AbdomViscArtR
				BrachiocephalicArt
				BronchialArt
				CommonCarotidArtL
				CommonCarotidArtR
				CoronaryArteryL
				CoronaryArteryR
				EsophagealArt
				ExternalIliacArtL
				ExternalIliacArtR
				IliacArtL
				IliacArtR
				IntercostalArt
				PulmonaryArteryL
				PulmonaryArteryR
				RenalArt
				SuperiorPhrenicArt
				SubclavianArtR
				SubclavianArtL
				InternalIliacArtL
				InternalIliacArtR
TissDistressTrans		SympAbdomViscNV	None	MedullaVasomotorReg
		SympExtIliacNV		
		SympSubclavianNV		
		SympEsophgNV		
		SympIntIliacNV		
		SympCarotidNV		
		SympBronchialNV		
		SympRenalNV		
TissueDistress	TissDistressh	LungTissue	MetabolicRate	SympBronchialNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressg	EsophagusTissue	MetabolicRate	SympEsophgNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressf	KidneyTissue	MetabolicRate	SympRenalNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistresse	AbdomViscera Tissue	MetabolicRate	SympAbdomViscNV
			pO2ofTissueGrp	
			pCO2Waste	

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
Diameter Diameter	Amount	IR
None	pO2TissGrp Location pCO2TissGrp whichProb	IR
None	pO2ofTissGrp pCO2ofTissGrp whichProblem	IR
None	pO2ofTissGrp whichProblem pCO2ofTissGrp	IR
None	pO2ofTissGrp pCO2ofTissGrp whichProblem	IR
None	pO2ofTissGrp pCO2ofTissGrp whichProblem	IR

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
	TissDistressd	IntIliacViscNParietTissue	MetabolicRate	SympIntIliacNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressc	LowerLimbTissue	MetabolicRate	SympExtIliacNV
			pO2ofTissueGrp	
			pCO2Waste	
	TissDistressb	HeadNeckSpineTissue	pO2ofTissueGrp	SympCarotidNV
			MetabolicRate	
			pCO2Waste	
	TissDistressa	UpperLimbTissue	MetabolicRate	SympSubclavianNV
			pO2ofTissueGrp	
			pCO2Waste	
DecreaseHeartStrok		VagusNV	None	Heart
IncreaseHeartStroke		SympatheticCardiac	None	Heart
HStrokeVolumeDecr		MedullaCardioReg	BPHeartSysMonitor	VagusNV
HStrokeVolumeIncrT		MedullaCardioReg	BPHeartSysMonitor	SympatheticCardiac
HeartRateCommand	ParasymIncreaseRa	VagusNV	None	Heart
	IncreaseRate	SympatheticCardiac	None	Heart
	DecreaseRate	VagusNV	None	Heart
HeartRateTrans	ParasymHeartRatel	MedullaCardioReg	None	VagusNV
	IncreaseHeartRate	MedullaCardioReg	None	SympatheticCardiac
	DecreaseHeartRate	MedullaCardioReg	None	VagusNV
ChemPHParasymTrans		MedullRecvSendComp	None	VagusNV
ChemPHSympTrans		MedullRecvSendComp	None	SympatheticCardiacNerve
RelaxTransA		InspiratoryCenter	None	PhrenicNV
				IntercostalNV
RelaxTransB		ExpiratoryCenter	None	AbdominalNV
				IntercostalNV
ContractTransA		InspiratoryCenter	None	IntercostalNV
				PhrenicNV
ContractTransB		ExpiratoryCenter	None	AbdominalNV
				IntercostalNV
Relax	RelaxAbdominals	AbdominalNV	None	Abdominal
	RelaxInternalInterco	IntercostalNV	None	InternalIntercostals
	RelaxExternalInterco	IntercostalNV	None	ExternalIntercostals
	RelaxDiaphragm	PhrenicNV	None	Diaphragm
Contract	ContractDiaphragm	PhrenicNV	None	Diaphragm
	ContractInternalInter	IntercostalNV	None	InternalIntercostals
	ContractExternalInte	IntercostalNV	None	ExternalIntercostals
	ContractAbdominals	AbdominalNV	None	Abdominal
ReturnToNormalpO2		VagusNV	None	MedullaCardioReg
		GlossopharyngealN		
LowpO2		VagusNV	None	MedullaCardioReg

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
None	pO2ofTissGrp pCO2ofTissGrp whichProblem	IR
None	pO2ofTissGrp pCO2ofTissGrp whichProblem	IR
None	pO2ofTissGrp pCO2ofTissGrp whichProblem	IR
None	pO2ofTissGrp whichProblem pCO2ofTissGrp	IR
StrokeVolume	Amount	IR
StrokeVolume	Amount	IR
None	Amount	IR
None	Amount	IR
HeartRate	Amount	IR
HeartRate	Amount	IR
HeartRate	Amount	IR
None	Amount	IR
None	Amount	IR
None	Amount	IR
None	DecreaseInSV DecreaseInHR	IR
None	IncreaseInHR IncreaseInSV	IR
None	Amount	IR
None	Amount	IR
None	Amount	IR
None	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
ContractionLevel	Amount	IR
BPHeartSysMonitor	pO2Value	IR
BPHeartSysMonitor	pO2Value	IR

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
		GlossopharyngealN		
IncreaseBP		GlossopharyngealN VagusNV	None	MedullaCardioReg
DecreaseBP		VagusNV GlossopharyngealN	None	MedullaCardioReg
AdminAlbut		Albuterol	None	BodyEnvironMatrix
SmokeStreamStim		smokeGasMixture	None	BodyEnvironMatrix
VaporCloudStim		localChemicalVaporCloud	None	BodyEnvironMatrix
MonoxideStim		CO	None	BodyEnvironMatrix
ParticleCloudStim		localParticleClusterCloud	None	BodyEnvironMatrix
AdminMetha		Methacholine	None	BodyEnvironMatrix
Manager.Federate	**Alert**	**Federate**	**None**	**Federate**

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
BPHeartSysMonitor	Amount	IR
	Location	
BPHeartSysMonitor	Amount	IR
	Location	
BodyAffectors	Dosage	IR
	ImmediacyofEffect	
	TargetSystem	
	PotLevelofInjury	
	IdentityProfile	
AirComponents	Duration	IR
Humidity	perCO2	
	perO2	
	perCO	
	IdentityProfile	
	PotLevelofInjury	
	perOtherInert	
	TargetSystem	
	ImmediacyofEffect	
BodyAffectors	Duration	IR
	Concentration	
	ImmediacyofEffect	
	TargetSystem	
	PotLevelofInjury	
	IdentityProfile	
AirComponents	Amount	IR
Humidity	Duration	
	ImmediacyofEffect	
	IdentityProfile	
	PotLevelofInjury	
	TargetSystem	
BodyAffectors	SizeOfParticles	IR
	Duration	
	ImmediacyofEffect	
	PotLevelofInjury	
	IdentityProfile	
	TargetSystem	
BodyAffectors	Dosage	IR
	ImmediacyofEffect	
	PotLevelofInjury	
	IdentityProfile	
	TargetSystem	
None	**AlertSeverity**	IR
	AlertText	
	AlertID	

Interaction Structure		Initiating Object		Receiving
		Class	Affected Attributes	Class
	ObjectInformation	Federate	None	Federate
	PublishingClass	Federate	None	Federate
	SubscribingClass	Federate	None	Federate
Manager.Federate.ServiceLog	ServiceLogArguments	Federate	None	Federate
Manager.Federate.Action	RequestPublicatio	Federate	None	Federate
	RequestSubscripti	Federate	None	Federate
	SetTiming	Federate	None	Federate
	RequestObjectInfor	Federate	None	Federate
	ModifyAttributeState	Federate	None	Federate
	Control	Federate	None	Federate
Manager.Federate.Action.RemoteServiceInvocation	DoResignFederatio	Federate	None	Federate
	DoDeleteObject	Federate	None	Federate
	DoSetLookahead	Federate	None	Federate
	DoSetTimeConstrai	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate
	DoTurnRegulation	Federate	None	Federate

bject/Area Affected Attributes	Interaction Parameters	Init/ Sense/ React
None	ObjectID	IR
	LockedAttributes	
	RegisteredClass	
	RepresentedClass	
None	ObjectClass	IR
	InteractionClass	
None	ObjectClass	IR
	InteractionClass	
None	Handle1	IR
	Handle2	
	HandleSet	
	ObjectIDorCount	
	TagOrLabelOrNam	
	Time	
	Enumeration	
	Boolean	
None	None	IR
None	None	IR
None	FedReportPeriod	IR
	TimeReportPeriod	
	ObjectReportPerio	
None	ObjectID	IR
None	ObjectID	IR
	AttributeID	
	TokenState	
None	SetServiceLogging	IR
	SetLogFile	
	DeleteObject	
	DequeueFIFO	
None	ResignAction	IR
None	ObjectID	IR
	Time	
	Tag	
None	Lookahead	IR
None	State	IR
None	None	IR
None	None	IR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
NervousDuctwork	TransmissionFactor	double	1
Heart	HeartRate	double	1
	StrokeVolume	double	1
	CardiacOutput	double	1
	PeripheralResistanceTotal	double	1
	ForceOfContraction	double	1
	BloodPressure	double	1
Lungs	LungVolume	double	1
	InternalLungPressure	double	1
	OverallAirwayResistance	double	1
	TidalVolume	double	1
	DeadAirSpace	double	1
	RespiratoryRate	double	1
	LungCompliance	float	1
	InspiratoryCapacity	float	1
	VitalCapacity	float	1
	TotalLungCapacity	float	1
	InspiratoryReserveVolume	float	1
	ExpiratoryReserveVolume	float	1
	ResidualVolume	float	1
IrritantSensor	Location	string	1
	Status	string	1
TissueGroups	MetabolicRate	double	1
	pCO2Waste	double	1
	pO2Demand	double	1
	PeripheralResistance	double	1
	O2ExtractionCoefficient	double	1
	PercentCardiacOutput	float	1
	pO2ofTissueGrp	float	1
Epiglottis	status	string	1
Human	HemoglobinBindingPercent	float	1
	Age	double	1
	Weight	double	1
	Temperature	float	1
	HumanState	HumanStateData	1
	ShuntFactor	double	1
ArteryinBody	pO2In	double	1
	FlowRate	double	1
	Diameter	double	1
	pCO2In	float	1
Aorta	pO2In	double	1
	pCO2In	double	1
	FlowRate	double	1
	Diameter	double	1
VeininBody	FlowRate	double	1
	Diameter	double	1

Units	Resolution	Accuracy	Accuracy Condition
N/A	hundredths	perfect	always
inverse time (per minute)	hundredths	perfect	always
ml	hundredths	perfect	always
ml/min	hundredths	perfect	always
		perfect	always
	tenths	perfect	always
mm Hg	hundredths	perfect	always
cm3	tenths	perfect	always
		perfect	always
		perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
inverse time (per minute)	tenths	perfect	always
L/cm H2O	hundredths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
ml	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
		perfect	always
		perfect	always
percentage	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
percentage	tenths	perfect	always
		perfect	always
		perfect	always
degrees Farenheit	tenths	perfect	always
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
mm Hg	tenths	perfect	always
	tenths	perfect	always
mm	tenths	perfect	always
mm Hg	tenths	perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
	tenths	perfect	always
	tenths	perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Static		N	UR
Conditional	If changed	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	TA	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	TA	UR
Static		TA	UR
Static		TA	UR
Periodic	Every cycle	TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	If changed	N	UR
Periodic	Every cycle	N	UR
Conditional	Every cycle	N	UR
Conditional	If changed	N	UR
Static		N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Static		N	UR
Periodic	Every cycle	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Periodic	Every cycle	TA	UR
Periodic	Every cycle	TA	UR
Periodic	Every cycle	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Conditional	Upon change	TA	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	pO2Out	float	1
	pCO2Out	float	1
Pharynx	Diameter	float	1
Larynx	Diameter	float	1
Trachea	Diameter	float	1
Bronchia	Diameter	float	1
SpinalColumn	CerebrospinalFluidPH	double	1
NasalCavity	NasalCavityVolume	double	1
	FlowRate	float	1
ThoracicCavity	ThoracicCavityVolume	float	1
PleuralCavity	PleuralCavityVolume	double	1
Abdominal	ContractionLevel	double	1
ExternalIntercostals	ContractionLevel	float	1
InternalIntercostals	ContractionLevel	double	1
Diaphragm	ContractionLevel	double	1
LungConductingZone	AirwayResistance	double	1
LungRespiratoryZone	pO2staleBlood	double	1
	pCO2staleBlood	double	1
	pO2InspiredAir	double	1
	pCO2InspiredAir	double	1
	CO2DiffCoeff	double	1
	O2DiffCoeff	double	1
	pO2Out	double	1
	pCO2Out	double	1
	DMinverse	float	1
	MembraneSurfaceArea	float	1
	MembraneThickness	float	1
	AveolarVentilationRate	double	1
BAROAorticArch	Location	double	1
	Status	double	1
	BPChange	double	1
	DirectionBPChange	string	1
BAROCarotidSinus	Location	string	1
	Status	string	1
	BPChange	double	1
	DirectionBPChange	string	1
MedullPHRecpt	Location	string	1
	pHCerebroSpinalFluid	double	1
	Status	string	1
CarotO2Recpt	Location	string	1
	pO2	double	1
	Status	string	1
AorticO2Recpt	Location	string	1
	pO2	double	1
	Status	string	1
HeartValves	Position	string	1

Units	Resolution	Accuracy	Accuracy Condition
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm	tenths	perfect	always
mm	tenths	perfect	always
mm	tenths	perfect	always
mm	tenths	perfect	always
	hundredths	perfect	always
cm3	integer value	perfect	always
ml/min	integer value	perfect	always
cm3	integer value	perfect	always
cm3	hundredths	perfect	always
percentage	hundredths	perfect	always
percentage	tenths	perfect	always
percentage	hundredths	perfect	always
percentage	hundredths	perfect	always
		perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
mm Hg	hundredths	perfect	always
ml/min/mm Hg	hundredths	perfect	always
ml/min/mm Hg	hundredths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
		perfect	always
cm2	tenths	perfect	always
mm	integer value	perfect	always
L/min	tenths	perfect	always
		perfect	always
		perfect	always
percentage	hundredths	perfect	always
		perfect	always
		perfect	always
		perfect	always
percentage	thousandths	perfect	always
		perfect	always
		perfect	always
	hundredths	perfect	always
N/A	N/A	perfect	always
		perfect	always
mm Hg	thousandths	perfect	always
N/A	N/A	perfect	always
		perfect	always
mm Hg	thousandths	perfect	always
		perfect	always
N/A	N/A	perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Periodic	Every cycle	TA	UR
Periodic	Every cycle	TA	UR
Static		TA	UR
Static		TA	UR
Static		TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Static		N	UR
Conditional	If changed	N	UR
Conditional	If changed	TA	UR
Conditional	If changed	TA	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Conditional	If changed	TA	UR
Periodic	Every Cycle	N	UR
Periodic	Every cycle	TA	UR
Periodic	Every Cycle	TA	UR
Periodic	Every Cycle	TA	UR
Static		TA	UR
Static		TA	UR
Periodic	Every Cycle	TA	UR
Periodic	Every Cycle	TA	UR
Static		TA	UR
Static		TA	UR
Conditional	If changed	TA	UR
Periodic	Every Cycle	TA	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	If changed	N	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
HeartChambers	HeartChamberVolume	float	1
	EfficiencyofContraction	float	1
	pO2In	double	1
	pO2Out	double	1
	pCO2In	double	1
	pCO2Out	double	1
MedullaVasomotorReg	status	string	1
	activityState	string	1
	BPMonitorTissues	string	1+
MedullaCardioReg	status	string	1
	activityState	string	1
	BPHeartSysMonitor	string	1+
MedullaRespirReg	status	string	1
	activityState	any	1
InspiratoryCenter	CycleTime	float	1
ExpiratoryCenter	CycleTime	float	1
MedulCO2Recpt	Location	string	1
	Status	string	1
	pCO2	float	1
BodyEnvironMatrix	ExternalTemp	float	1
	AirPressure	float	1
	Altitude	float	1
	LocationData	LocationXY	1
	Humidity	float	1
	AirComponents	AirConstituentPercent	1
	BodyAffectors	string	1+
airMixture	perO2	float	1
	perN2	float	1
	perCO2	float	1
	altitude	float	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	LocationXY	XYCoorData	1
smokeGasMixture	perCO2	float	1
	perO2	float	1
	perCO	float	1
	perOtherInert	float	1
	IndentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
localParticleClusterCloud	SizeofParticles	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+

Units	Resolution	Accuracy	Accuracy Condition
cm3	integer value	perfect	always
percentage	nearest integer	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
sec	tenths	perfect	always
sec	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
degrees Farenheit	integer value	perfect	always
mm Hg	tenths	perfect	always
m	integer value	perfect	always
N/A	N/A	N/A	N/A
percentage	integer value	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
m	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
microns	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
microns	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Conditional	Every Cycle	N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	N	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	N	UR
Conditional	Upon change	TA	UR
Conditional	Upon change	TA	UR
Conditional	If changed	N	UR
Conditional	If changed	N	UR
Static		N	UR
Conditional	Upon change	N	UR
Conditional	Upon change	N	UR
Conditional	If changed	TA	UR
Static		TA	UR
Static		TA	UR
Conditional	If changed	TA	UR
Conditional	Upon change	N	UR
Conditional	If changed	TA	UR
Conditional	If changed	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	IndentityProfile	IdentityProfileData	1
	TargetSystem	string	1
localChemicalVaporCloud	Concentration	float	1
	IdentityProfile	IdentityProfileData	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
gas	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
volatileChemicalVaporCloud	LocationXY	XYCoorData	1
	CloudDiameter	float	1
	Concentration	float	1
	Altitude	float	1
	LocationLL	LocationLLData	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	Speed	float	1
	DirectionofMotion	XYCoorData	1
O2	AmtO2	float	1
CO2	AmtCO2	float	1
CO	AmtCO	float	1
particleClusterCloud	LocationXY	XYCoorData	1
	LocationLL	LocationLLData	1
	ParticleSizeGroups	ParticleSizeGroupList	1
	Altitude	float	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	Speed	float	1
	DirectionofMotion	XYCoorData	1
Methacholine	Dosage	float	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	ImmediacyofEffect	ImmediacyofEffectData	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
Albuterol	Dosage	double	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	IdentityProfile	IdentityProfileData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
Federate	**FederateHost**	**string**	**1**

Units	Resolution	Accuracy	Accuracy Condition
N/A	N/A	N/A	N/A
		perfect	always
mg/m^3	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
m	tenths	perfect	always
mg/m^3	tenths	perfect	always
m	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
km/sec	tenths	perfect	always
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
m	tenths	perfect	always
N/A	N/A	N/A	N/A
		perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
km/sec	tenths	perfect	always
N/A	N/A	N/A	N/A
gm/ml	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
gm/ml	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	upon "big enough" change	N	UR
Conditional	If sizes drop out;physics alg	N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional		N	UR
Conditional	upon "big enough" change	N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Static		N	UR
Conditional		**N**	**UR**

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	FederateHandle	**string**	**1**
	FederateState	**string**	**1**
	FederateName	**string**	**1**
	RTIversion	**string**	**1**
	TimeManagerState	**string**	**1**
	FederateLookahead	**string**	**1**
	FederateTime	**string**	**1**
	TimeConstrained	**string**	**1**
	TimeRegulating	**string**	**1**
	FIFOlength	**string**	**1**
	TSOlength	**string**	**1**
	DequeueFIFOasync	**string**	**1**
	TotalObjectCount	**string**	**1**
	HoldingTokensObjectCou	**string**	**1**
	DeletedObjectCount	**string**	**1**
	NumAttributes	**string**	**1**
	NumParameters	**string**	**1**
Federation	**FederationName**	**string**	**1**
	FederationState	**string**	**1**
	FederatesInFederation	**string**	**1**
	SaveIsScheduled	**string**	**1**
	ScheduledSaveTime	**string**	**1**
	RTIversion	**string**	**1**
ChangeCycleTime	Direction	string	1
	CycleChange	float	1
ConstrictBronchioles	Amount	float	1
TissDistressTrans	pO2TissGrp	float	1
	Location	string	1
	pCO2TissGrp	float	1
	whichProb	string	1
DecreaseHeartStrokeVolum	Amount	float	1
IncreaseHeartStrokeVolum	Amount	double	1
HStrokeVolumeDecrTrans	Amount	float	1
HStrokeVolumeIncrTrans	Amount	double	1
ChemPHParasymTrans	DecreaseInSV	float	1
	DecreaseInHR	float	1
ChemPHSympTrans	IncreaseInHR	float	1
	IncreaseInSV	float	1
RelaxTransA	Amount	double	1
RelaxTransB	Amount	double	1
ContractTransA	Amount	double	1
ContractTransB	Amount	double	1
ContractDiaphragm	Amount	double	1
ContractInternalIntercostals	Amount	double	1
ContractExternalIntercostal	Amount	float	1
ContractAbdominals	Amount	double	1

Units	Resolution	Accuracy	Accuracy Condition
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
N/A	N/A	perfect	always
sec	tenths	perfect	always
percentage	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage		perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
		perfect	always
		perfect	always
percentage	tenths	perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
Conditional		N	UR
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
RelaxAbdominals	Amount	double	1
RelaxInternalIntercostals	Amount	double	1
RelaxExternalIntercostals	Amount	float	1
RelaxDiaphragm	Amount	double	1
ParasymHeartRateIncrease	Amount	float	1
IncreaseHeartRate	Amount	double	1
DecreaseHeartRate	Amount	double	1
ParasymIncreaseRate	Amount	float	1
IncreaseRate	Amount	double	1
DecreaseRate	Amount	double	1
DilateArtery	Amount	double	1
ConstrictArtery	Amount	double	1
ReturnToNormalpO2	pO2Value	float	1
LowpO2	pO2Value	double	1
IncreaseBP	Amount	double	1
	Location	string	1
DecreaseBP	Amount	double	1
	Location	string	1
AveolarIrritantSensed	Location	string	1
BronchioleIrritantSensed	Location	string	1
LarynxIrritantSensed	Location	string	1
TrachealIrritantSensed	Location	string	1
TissDistressh	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressg	pO2ofTissGrp	float	1
	whichProblem	string	1
	pCO2ofTissGrp	float	1
TissDistressf	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistresse	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressd	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressc	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressb	pO2ofTissGrp	float	1
	pCO2ofTissGrp	float	1
	whichProblem	string	1
TissDistressa	pO2ofTissGrp	any	1
	whichProblem	string	1
	pCO2ofTissGrp	float	1

Units	Resolution	Accuracy	Accuracy Condition
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
	integer value	perfect	always
	integer value	perfect	always
percentage	tenths	perfect	always
	integer value	perfect	always
	integer value	perfect	always
percentage	hundredths	perfect	always
percentage	hundredths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	perfect	always
percentage	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
		perfect	always
mm Hg	tenths	perfect	always
mm Hg	tenths	perfect	always
N/A	N/A	perfect	always
		perfect	always
N/A	N/A	perfect	always
mm Hg	thousandths	perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
TracActIS	TurnOn	string	1
	LevelofIrritant	string	1
LaryActIS	TurnOn	string	1
	LevelofIrritant	string	1
BronActIS	TurnOn	string	1
	LevelofIrritant	string	1
AvelActIS	TurnOn	string	1
	LevelofIrritant	string	1
AdminAlbut	Dosage	double	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
SmokeStreamStim	Duration	float	1
	perCO2	float	1
	perO2	float	1
	perCO	float	1
	IdentityProfile	IdentityProfileData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	perOtherInert	float	1
	TargetSystem	string	1
	ImmediacyofEffect	ImmediacyofEffectData	1
VaporCloudStim	Duration	float	1
	Concentration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	TargetSystem	string	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	IdentityProfile	IdentityProfileData	1
MonoxideStim	Amount	float	1
	Duration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	IdentityProfile	IdentityProfileData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	TargetSystem	string	1
ParticleCloudStim	SizeOfParticles	float	1
	Duration	float	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
AdminMetha	Dosage	double	1
	ImmediacyofEffect	ImmediacyofEffectData	1
	PotLevelofInjury	GenericInjuryLevelInfo	1+
	IdentityProfile	IdentityProfileData	1
	TargetSystem	string	1
Alert	**AlertSeverity**	**string**	**1**

Units	Resolution	Accuracy	Accuracy Condition
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
N/A	N/A	perfect	always
		perfect	always
N/A	N/A	perfect	always
gm/ml	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
sec	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
percentage	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
percentage	nearest integer	perfect	always
mg/m^3	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
percentage	tenths	perfect	always
sec	tenths	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
microns	nearest integer	perfect	always
sec	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
gm/ml	nearest integer	perfect	always
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	perfect	always
		perfect	**always**

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	**N/A**	**N/A**	**N/A**

Object/Interaction	Attribute/Parameter	Datatype	Cardinality
	AlertText	string	1
	AlertID	string	1
ServiceLogArguments	Handle1	string	1
	Handle2	string	1
	HandleSet	string	1
	ObjectIDorCount	string	1
	TagOrLabelOrName	string	1
	Time	string	1
	Enumeration	string	1
	Boolean	string	1
ObjectInformation	ObjectID	string	1
	LockedAttributes	string	1
	RegisteredClass	string	1
	RepresentedClass	string	1
PublishingClass	ObjectClass	string	1
	InteractionClass	string	1
SubscribingClass	ObjectClass	string	1
	InteractionClass	string	1
SetTiming	FedReportPeriod	string	1
	TimeReportPeriod	string	1
	ObjectReportPeriod	string	1
RequestObjectInformatio	ObjectID	string	1
ModifyAttributeState	ObjectID	string	1
	AttributeID	string	1
	TokenState	string	1
DoResignFederationExec	ResignAction	string	1
DoDeleteObject	ObjectID	string	1
	Time	string	1
	Tag	string	1
DoSetLookahead	Lookahead	string	1
DoSetTimeConstrained	State	string	1
Control	SetServiceLogging	string	1
	SetLogFile	string	1
	DeleteObject	string	1
	DequeueFIFO	string	1

Units	Resolution	Accuracy	Accuracy Condition
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
		perfect	always
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		perfect	always
		perfect	always

Update Type	Update Condition	Transferable/Acceptable	Updateable/Reflectable
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A

Identifier	Enumerator	Representation
HumanStateData	Alive	1
	Dead	2
InjuryLevelData	critical	1
	serious	2
	minor	3
	none	4
	unknown	5
ImmediacyofEffectData	Immediate	1
	Seconds	2
	FewMinutes	3
	Hour	4
	FewHours	5
	SeveralHours	6
	TwelveHours	7
	Day	8
	Days	9
	Week	10
	Weeks	11
	Month	12
	LongTerm	13

Complex Datatype	Field Name	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
LocationXY	X	float	1	m	integer valu	perfect	always
	Y	float	1	m	integer valu	perfect	always
AirConstituentPercent	COper	float	1	percentage	integer valu	perfect	always
	Argonper	float	1	percentage	integer valu	perfect	always
	O2per	float	1	percentage	integer valu	perfect	always
	CO2per	float	1	percentage	integer valu	perfect	always
	N2per	float	1	percentage	integer valu	perfect	always
ParticleSizeGroupList	SmallSize	boolean	1	N/A	N/A	perfect	always
	MediumSiz	boolean	1	N/A	N/A	perfect	always
	LargeSize	boolean	1	N/A	N/A	perfect	always
LocationLLData	Latitude	LatLongCo	1	N/A	N/A	N/A	N/A
	Longitude	LatLongCo	1	N/A	N/A	N/A	N/A
LatLongCoordFormat	degrees	double	1	N/A	N/A	perfect	always
	minutes	double	1	N/A	N/A	perfect	always
XYCoorData	X	float	1	km	hundredths	perfect	always
	Y	float	1	km	hundredths	perfect	always
IdentityProfileData	Bronchioco	boolean	1	N/A	N/A	perfect	always
	BronchioDil	boolean	1			perfect	always
	AveloiInfla	boolean	1	N/A	N/A	perfect	always
	ModifyAirP	boolean	1			perfect	always
	ModifyAmb	boolean	1			perfect	always
	ModifyAmb	boolean	1			perfect	always
	BindHEM	boolean	1	N/A	N/A	perfect	always
GenericInjuryLevelInfo	Level	any	1			perfect	always
	PotentialInj	InjuryLevel	1	N/A	N/A	N/A	N/A

Class	Component	Component
Larynx	Epiglottis	
CardiovascularSystem	HeartValves	
	Heart	HeartChambers
		HeartValves
	HeartChambers	
	CardiovascularDuctwork	
	HeartTissue	
RespiratorySystem	ThoracicCavity	
	RespiratoryDuctwork	
	LungConductingZone	
	LungRespiratoryZone	
	Lungs	LungRespiratoryZone
		LungConductingZone
		LungTissue
	LungTissue	
	PleuralCavity	
	RespiratoryMuscles	
smokeGasMixture	CO	
	CO2	
	O2	

Class	Association	Class
AorticO2Recpt	MemberPartnerA	VagusNV (Transmit info from s
CarotO2Recpt	MemberPartnerB	GlossopharyngealNV
BAROAorticArch	MemberPartnerC	VagusNV
BAROCarotidSinus	MemberPartnerD	GlossopharyngealNV
MedullPHRecpt	AssocStructureA	MedullaCardioReg
SympAbdomViscNV	Serves1	AbdomViscArtL
SympatheticCardiacNerve	Serves2	Heart
SympBronchialNV	Serves3	BronchialArt
SympCarotidNV	Serves4	CommonCarotidArtL
SympEsophgNV	Serves5	EsophagusTissue
SympExtIlliacNV	Serves6	ExternalIlliacArtR
SympIntIlliacNV	Serves7	InternalIlliacArtL
SympRenalNV	Serves8	RenalArt
SympSubclavianNV	Serves9	SubclavianArtL
AbdominalNV	Serves10	AbdomParietArtL
GlossopharyngealNV	Serves11	Heart
IntercostalNV	Serves12	IntercostalArt
PhrenicNV	Serves13	Diaphragm
VagusNV	Serves14	Heart
PhrenicVein	Drains1	Diaphragm
AzygosVein	Drains2	EsophagusTissue
CoronaryVeinR	Drains3	HeartTissue
CoronaryVeinL	Drains4	HeartTissue
ExternalIlliacVeinR	Drains5	LowerLimbTissue
ExternalIlliacVeinL	Drains6	LowerLimbTissue
HepaticPortalVein	Drains7	AbdomVisceraTissue
InternalIlliacVeinL	Drains8	IntIlliacViscNParietTissue
InternalIlliacVeinR	Drains9	IntIlliacViscNParietTissue
JugularVeinsL	Drains10	HeadNeckSpineTissue
JugularVeinsR	Drains11	HeadNeckSpineTissue
SubclavianVeinL	Drains12	UpperLimbTissue
SubclavianVeinR	Drains13	UpperLimbTissue
InferiorVenaCava	Transports1	HepaticPortalVein
SuperiorVenaCava	Transports2	AzygosVein
LungRespiratoryZone	PulmonaryRt6	PulmonaryArteryL 2
LungRespiratoryZone	PulmonaryRt7	PulmonaryArteryR 2
AtriaRight	PulmonaryRt1	InferiorVenaCava
InferiorVenaCava	FormedBy1	InternalIlliacVeinL
BrachiocephalicVeinL	FormedBy2	SubclavianVeinL
BrachiocephalicVeinR	FormedBy3	SubclavianVeinR
VentricleRight	PulmonaryRt2	AtriaRight
PulmonaryTrunk	PulmonaryRt3	VentricleRight
PulmonaryArteryL 2	PulmonaryRt4	PulmonaryTrunk
PulmonaryArteryR 2	PulmonaryRt5	PulmonaryTrunk
PulmonaryVeinsL 2	PulmonaryRt8	LungConductingZone
PulmonaryVeinsR 2	PulmonaryRt9	LungRespiratoryZone
AtriaLeft	PulmonaryRt10	PulmonaryVeinsL 2

Class	Class	Class
AbdomViscArtR	AbdomViscera Tissue	
HeartTissue	CoronaryArteryL	CoronaryArteryR
LungTissue		
CommonCarotidArtR	HeadNeckSpineTissue	
EsophagealArt		
ExternalIlliacArtL	LowerLimbTissue	
InternalIliacArtR	IntIlliacViscNParietTissue	
KidneyTissue		
SubclavianArtR	UpperLimbTissue	
Abdominal	AbdomParietArtR	
InternalIntercostals	ExternalIntercostals	
SuperiorPhrenicArt		
InternalIntercostals	ExternalIntercostals	LungTissue
PhrenicVein	RenalVein	
BrachiocephalicVeinR	BrachiocephalicVeinL	
SuperiorVenaCava	CoronaryVeinR	CoronaryVeinR
InternalIliacVeinR	ExternalIliacVeinR	ExternalIliacVeinL
JugularVeinsL		
JugularVeinsR		

Class
Abdominal

Class	Association	Class
AtriaLeft	PulmonaryRt11	PulmonaryVeinsL 2
VentricleLeft	PulmonaryRt12	AtriaLeft
Aorta	PulmonaryRt13	VentricleLeft
PulmonaryTrunk	PulmonarySC1	CoronaryVeinR
PulmonaryArteryL 2	PulmonarySC2	PulmonaryTrunk
PulmonaryArteryR 2	PulmonarySC3	PulmonaryTrunk
LungRespiratoryZone	PulmonarySC4	PulmonaryArteryL 2
LungRespiratoryZone	PulmonarySC5	PulmonaryArteryR 2
PulmonaryVeinsL 2	PulmonarySC6	LungRespiratoryZone
PulmonaryArteryR 2	PulmonarySC7	LungRespiratoryZone
Aorta	PulmonarySC8	PulmonaryVeinsL 2
Aorta	PulmonarySC9	PulmonaryArteryR 2
AorticArch	SystCircDel1	Aorta
DescendingAorta	SystCircDel2	Aorta
AscendingAorta	SystCircDel3	Aorta
CoronaryArteryL	SystCircDel4	AscendingAorta
CoronaryArteryR	SystCircDel5	AscendingAorta
BrachiocephalicArt	SystCircDel6	AorticArch
CommonCarotidArtL	SystCircDel7	AorticArch
SubclavianArtL	SystCircDel8	AorticArch
CommonCarotidArtR	SystCircDel9	BrachiocephalicArt
SubclavianArtR	SystCircDel10	BrachiocephalicArt
AbdomParietArtL	SystCircDel11	DescendingAorta
AbdomParietArtR	SystCircDel12	DescendingAorta
AbdomViscArtL	SystCircDel13	DescendingAorta
AbdomViscArtR	SystCircDel14	DescendingAorta
BronchialArt	SystCircDel15	DescendingAorta
EsophagealArt	SystCircDel16	DescendingAorta
IliacArtL	SystCircDel17	DescendingAorta
IliacArtR	SystCircDel18	DescendingAorta
IntercostalArt	SystCircDel19	DescendingAorta
RenalArt	SystCircDel20	DescendingAorta
SuperiorPhrenicArt	SystCircDel21	DescendingAorta
InternalIliacArtL	SystCircDel22	IliacArtL
ExternalIliacArtL	SystCircDel23	IliacArtL
ExternalIliacArtR	SystCircDel24	IliacArtR
InternalIliacArtR	SystCircDel25	IliacArtR
AbdomViscera Tissue	Supplied1	AbdomViscArtL
AbdomViscera Tissue	Supplied2	AbdomViscArtR
Diaphragm	Supplied3	SuperiorPhrenicArt
Esophagus Tissue	Supplied4	EsophagealArt
HeadNeckSpine Tissue	Supplied5	CommonCarotidArtL
HeadNeckSpine Tissue	Supplied6	CommonCarotidArtR
Heart Tissue	Supplied7	CoronaryArteryL
Heart Tissue	Supplied8	CoronaryArteryR
IntIliacViscNParietTissue	Supplied9	InternalIliacArtR
IntIliacViscNParietTissue	Supplied10	InternalIliacArtL

Class	Class	Class
CoronaryVeinL	InferiorVenaCava	SuperiorVenaCava

Class

Class	Association	Class
KidneyTissue	Supplied11	RenalArt
LowerLimbTissue	Supplied12	ExternalIlliacArtL
LowerLimbTissue	Supplied13	ExternalIlliacArtR
LungTissue	Supplied14	BronchialArt
UpperLimbTissue	Supplied15	SubclavianArtR
UpperLimbTissue	Supplied16	SubclavianArtL
ExpiratoryCenter	Reciprocal	InspiratoryCenter
Pneumotaxic/IntegrationCenter	MonitorsNIntegrates	MedullaVasomotorReg
Pneumotaxic/IntegrationCenter	Reset	ExpiratoryCenter

Class	Class	Class
MedullaCardioReg		
InspiratoryCenter		

Class

Term	Definition
MedullaRegulatoryCenter	The functional view of the medulla as a regulator of important body functions involving
OrganicDuctwork	organic conduits in the body
NervousDuctwork	nervous system fiber (nerves)
RespiratoryDuctwork	conduits in the respiratory system
CardiovascularDuctwork	conduits in the cardiovascular system
Organs	Body parts that are usually classed as organs
Heart	The pump of the body. It has components.
Lungs	major organ of respiration
OrganicRCPTRS	organic type sensors in the body
ChemoReceptor	sensor to sense pH or pO2 or pCO2 levels in the blood or cerebrospinal fluid
BaroReceptor	sensor to sense pressure changes in arteries
IrritantSensor	Senses physical irrritant, such as ash particle.
TissueGroups	body tissue arranged by groups and defined according to what artery feeds the tissue
Cavities	body part involving a spatial region which is connected to another by an opening
Chambers	body part region involving open or semi-open space which may be filled
Valves	body part mimicing a mechanical valve
Epiglottis	unpaired cartilege ; a part of the larynx, that flaps open or closed
LumpedZones	Sections of the body that are partitioned for calculations involving some subsytem suc
Human	overal entity associated with the body SOM
ArteryinBody	conduit which carries blood away from the heart
Aorta	primary artery of the body from which all other arteries descend, the aorta is 2.8 cm in
VeininBody	conduit which carries blood to the heart
Pharynx	Body part- common opening of the respiratory and digestive tracts
Larynx	Body part-nine joined cartilege rings that form part of the upper respiratory system
Trachea	body part-- the windpipe--a tubular part of the upper respiratory system--follows the lar
Bronchia	tubular branching passageway part of the respiratory system
SympAbdomViscNV	Sympathetic nerve going to the abdominal viscera artery -- involved in vasomotor com
SympEsophgNV	Sympathetic nerve going to the esophageal artery -- involved in vasomotor commands
SympCarotidNV	Sympathetic nerve going to the carotid arteries -- involved in vasomotor commands
SympSubclavianNV	Sympathetic nerve going to the subclavian artery; involved in vaomotor commands.
SympIntIlliacNV	Sympathetic nerve going to the Internal Illiac arteries-- involved in vasomotor comman
SympExtIlliacNV	Sympathetic nerve which goes to the external illiac arteries; involved in vasomotor co
SympRenalNV	Sympathetic nerve going to the kidney artery; involved in vasomotor commands to art
SympBronchialNV	Sympathetic nerve which goes to the Lung Tissue Bed artery; involved in vasomotor
SympatheticCardiacNerve	nerve running to the heart -- sympathetic stimulation nerve.
AbdominalNV	nerve ennervating the abdominal muscle/ tissue group. important for respiration.
IntercostalNV	Nerve going to the intercostal muscle--important in respiration.
GlossopharyngealNV	nerve running to the heart
PhrenicNV	nerve running to the diaphragm--important in respiration.
VagusNV	nerve running to the heart
SpinalColumn	nerves associated with the spinal column; like telephone cables
NasalCavity	cavity between the nostrils of the nose and the pharynx
ThoracicCavity	Cavity area of thorax in the physical human body. Lungs situated in this cavity. this ca
PleuralCavity	potential space between the parietal and visceral layers of the pleura
UpperLimbTissue	Tissue group served by subclavian arteries, left and right.
HeadNeckSpineTissue	Tissue group served by common carotid arteries, left and right.
LowerLimbTissue	Tissue group served by external illiac arteries, left and right.

Term	Definition
IntIlliacViscNParietTissue	Tissue group served by the internal illiac arteries, right and left.
AbdomViscera Tissue	Tissue group served by AbdomViscArt left and right, the abdominal viscera arteries, le
KidneyTissue	Tissue group served by the renal artery.
HeartTissue	Muscle tissue group that is the heart, served by the coronary arteries left and right.
EsophagusTissue	Tissue group served by the esophegeal artery.
LungTissue	Tissue group served by the bronchial artery.
RespiratoryMuscles	muscles used in inhaling and exhaling
Abdominal	Tissue (muscle) served by the Abdominal Parietal Arteries, left and right. This is a m
ExternalIntercostals	Muscles involved in inspiration;elevates the ribs. Served by the intercostal artery .
InternalIntercostals	Muscle tissue group also served by the Intercostal Art, the intercostal artery. This i
Diaphragm	Muscle tissue served by the superior Phrenic artery. This is a muscle of respiration.
CO2Sensor	Chemo sensor to sense CO2 levels in the blood or cerebrospinal fluid.
PHSensor	Sensor class to determine pH of blood or of cerebrospinal fluid.
O2Sensor	General class of sensor to determine partial pressure of O2.
ExternalIlliacArtR	This artery serves the right lower limb.
ExternalIlliacArtL	This artery serves the left lower limb.
InternalIlliacArtR	This artery serves the right pelvis rand right lower back
InternalIlliacArtL	This artery serves the left pelvis and left lower back region
IlliacArtR	this is the common illiac artery right which is formed by the split of the descending aort
IlliacArtL	this is the left common illiac artery; it is a continuation of the descending aorta at the a
AbdomParietArtL	serves the back muscles and the abdominal walls on the left
AbdomParietArtR	supplies the abdominal wall and the back region on the right
AbdomViscArtL	serves the left abdominal viscera tissues; except for the kidneys
AbdomViscArtR	artery serves abdominal viscera; right side; except for the kidneys
RenalArt	Serves the kidney tissue group.
EsophagealArt	Serves the esophagus tissue group, carries oxygen.
IntercostalArt	serves the intercostal muscle tissue, carries oxygen.
BronchialArt	Seves the lung tissue group, carries oxygen.
SuperiorPhrenicArt	serves the diaphragm muscle tissue group, carries oxygen
SubclavianArtL	This artery is the third branch off of the aortic arch. It transports blood to the upper lim
CommonCarotidArtL	This artery branches off of the aortic arch. It transports blood to the left side of the hea
SubclavianArtR	This branches off of the brachiocephalic artery and transpots blood to the upper limb (
CommonCarotidArtR	This artery branches from the brachiocephalic artery , and transports blood to the right
BrachiocephalicArt	first vessel(artery) to branch from the aortic arch; if branches to form the right common
CoronaryArteryR	the right branch of the ascending aorta
CoronaryArteryL	the left branch of the ascending aorta, serves the heart tissue left side
PulmonaryArteryR	artery which bifurcates off of the pulmonary trunk in the right direction and carries bloo
PulmonaryArteryL	artery which bifurcates off of the pulmonary trunk in the left direction and carries blood
PulmonaryTrunk	short arterial vessel (5 cm long) which comes off of the right ventricle of the heart; an
LungConductingZone	Bulk flow part of airways; no gas exchange
LungRespiratoryZone	Conceptual part of the respiratory system; a natural partition into which falls the attribu
DescendingAorta	the descending branch off of the aorta
AscendingAorta	the ascending branch off of the aorta
AorticArch	the branching of the aorta posteriorly and to the left which forms an arch shape
InternalIlliacVeinR	Drains the IntIlliacViscNParietTissue right side, and joins with the external illiac vein ri
InternalIlliacVeinL	Drains the IntIlliacViscNParietTissue left side, and joins with the external illiac vein to f
ExternalIlliacVeinR	Drains the lower limb tissue group right side, and unites with the internal illiac to ultima

Term	Definition
ExternalIlliacVeinL	Drains the lower limb tissue group --left side.
SuperiorVenaCava	Transport Vein. Major conduit returning blood from the azygos , the right and left brac
InferiorVenaCava	Transport Vein. Vein conduit into heart which is formed by the illiac veins, and returns
RenalVein	drains the kidney tissue group. Empties into the inferior vena cava transport vein.
PhrenicVein	Drains the diaohragm muscle tissue group; empties into the inferior vena cava, a trans
HepaticPortalVein	Drains the AbdomVisceraTissue group, empties into the inferior vena cava, a transpor
AzygosVein	Drains the Esophagus Tissue group, the Intercostal Tissue groups, the lung tissue, a
BrachiocephalicVeinR	Transport vein -- returns blood to the superior vena cava from the right side.
BrachiocephalicVeinL	transport vein -- to the superior vena cava (from left)
SubclavianVeinR	Drains the Upper Limb Tissue (right side) and joins with the right jugular vein to form
SubclavianVeinL	vein draining upper limb tissue (left) ; it joins with the jugular vein (L) to form left brach
JugularVeinsR	drains HeadNeckSpine tissue group (right side) . Joins with the subclavian vein (right)
JugularVeinsL	Drains HeadNeckSpine tissue group (left side). Joins with the subclavian vein to for
PulmonaryVeinsR	right pulmonary veins (2) carrying blood from the lung to the right atrium of the heart ;
PulmonaryVeinsL	left pulmonary veins (2) carrying blood from the lungs to the left atrium
CoronaryVeinR	transport blood from heart tissue (right side) to the right atrium
CoronaryVeinL	transports blood from heart tissue (left side) to the right atrium of the heart
BAROAorticArch	The pressure sensor for the aortic arch.
BAROCarotidSinus	The pressure sensor for the carotid sinous body.
MedulPHRecpt	pH sensor in the medulla; senses thepH of cerebrospinal fluid.
CarotO2Recpt	The O2 sensor in the carotid body.
AorticO2Recpt	The O2 sensor in the aorta
HeartValves	Valves found in the physical human heart.
AorticSemiLunarValve	valve in physical human heart between the left ventricle and the aorta; opens to let flo
PulmonarySemiLunarValve	valve in the physical human heart beween the right ventricle and the pulmonary trunk
MitralValve	Valve in the physical human heart between the left atrium and the left ventricle. Blood
TricuspidValve	Valve in the physical human heart between also between the right ventricle and the pu
HeartChambers	Chamber - like areas in the heart
VentricleLeft	Chamber in the physical human heart.
VentricleRight	Chamber in the physical human heart.
AtriaLeft	Chamber in the physical human heart
AtriaRight	Chamber in the physical human heart
MedullaVasomotorReg	The medulla's vasomotor regulatory center.
MedullaCardioReg	The medulla's cardio regulatory center
MedullaRespirReg	The medulla' s respiratory regulatory system.
InspiratoryCenter	A type of respiratory center in the medulla
ExpiratoryCenter	A type of respiratory center in the medulla
Pneumotaxic/IntegrationCe	A type of respiratory center in the medulla; it modifies the length of the cycle time (bre
MedulCO2Recpt	The CO2 sensor in the medulla receive compute send region
CardiovascularSystem	The physiological system in the human body pertaining to blood flow through the heart
RespiratorySystem	Physiological system pertaining to breathing and oxygenation; an abstract class comp
AveolarIrritantSensor	Biological sensor (cells) in the Lung REspiratory Zone which sense the presense of irri
BronchioleIrritantSensor	Biological sensors (cells) in the RemainingBronchiaNetwork which sense the presenc
LarynxIrritantSensor	Biological sensors (cells) in the larynx which sense the presense of irritants such as a
TrachealIrritantSensor	Biological sensor (cells) in the trachea which sense the presence of irritants such as
BodyEnvironMatrix	The environmental matrix surrounding the body
airMixture	The environmental air surrounding the body; used in more non-local and potentially ch

Term	Definition
smokeGasMixture	The mixture of gases which are to be inhaled by the human and which form the gases
localParticleClusterCloud	A small cloud of particles nearby the body; involved in interactions; used in local repre
localChemicalVaporCloud	A small chemical vapor cloud that is nearby the body, and is used in interactions; local
gas	One of the states of matter; refers to stimuli in this state; stimuli serves to evoke body
volatileChemicalVaporClou	Vapors of volatile chemicals which affect the respiratory system. Used for more globa
O2	oxygen in the stimulus
CO2	carbon dioxide – in the stimuli
CO	Carbon Monoxide in the stimulus
particleClusterCloud	Small particles found in smoke which serve as irritants to the human respiratory syste
MedicalDrugs	Drug stimuli which are given in a medical context
MedullRecvSendComp	The overall medulla
Methacholine	A medical drug which causes dilation of the bronchial passages
Albuterol	A drug which causes constriction of the bronchial tubes
Manager	**Manager class for the management object model.**
Federate	**Manager subclass for federates specific information.**
Federation	**Manager subclass for federation specific information.**

Term	Definition
StartExpiratory	Message to start the expiratory sequence
CeaseInhale	When the epiglottis closes, the inhalation ceases.
InflationMaximum	The lungs are at their maximum inflation
ChangeCycleTime	Modify the breathing period for the recipient center
OpenEpiglottis	Message to open the epiglottis;used in respiration
CloseEpiglottis	Message to close the epiglottis; used in the cough sequence.
ConstrictBronchioles	The effective diameter of the Bronchia is being reduced due to the presence of an irrit
IrritantSensed	interaction superclass whose subclasses are specific interactions communicating that
IrrSensorActivated	One of the irritant sensors has been activated by particulate matter hitting it
ChangeArteryDiameterCom	interaction to change the diameter of an artery. this affects the flow rate
TissDistressTrans	Transmitting of the tissue distress signal from the sympathetic nerve to the vasomotor
TissueDistress	This interaction involves the tissue groups needs for oxygen and waste (CO_2) eliminat
DecreaseHeartStrokeVolum	Command to decrease the heart stroke volume; from parasympathetic nervous syste
IncreaseHeartStrokeVolum	command to change the stroke volume of the heart-- from sympathetic cardiac erve t
HStrokeVolumeDecrTrans	transmission from the cardio reg center in the medulla to the parasympathetic nerve g
HStrokeVolumeIncrTrans	message from medulla to sympathetic cardiace nerve to relay message to heart chan
HeartRateCommand	message from nerves to heart to change the heart rate
HeartRateTrans	message from medulla to specfic nerves to relay message to heart to change the hear
ChemPHParasymTrans	Message transmitted from the medulla to the parasym nerves going to the heart; due t
ChemPHSympTrans	Transmission of data from the medulla as a result of pH too low (CO_2 too high) from s
RelaxTransA	message from inspiratory center to specific nerves involved in inspiration to relay a rel
RelaxTransB	Transmitted message from expiratory center to nerves involved in expiration to relax
ContractTransA	message from inspiratory center to specific nerves involved in inspiration to tell them t
ContractTransB	Message from expiratory center to nerves involved in expiration to contract.
Relax	a m,essage to relax the muscles--increase the length
Contract	a message to contract the muscles--lessen the length
ContractDiaphragm	message to contract the diaphragm muscles --used in breathing
ContractInternalIntercostals	message to contract the internal intercostal muscles used in breathing--the expiratory
ContractExternalIntercostal	Contract the external intercostals--muscles used for the inspiratory part of breathing
ContractAbdominals	message to abdominal muscles to contract -- these muscles used in breathing
RelaxAbdominals	a message to relax the abdominal muscles -- used in breathing
RelaxInternalIntercostals	a message to relax the intercostal muscles --used in breathing
RelaxExternalIntercostals	Relax the external intercostal muscles -- used in inspiration (breathing in)
RelaxDiaphragm	a message to relax the diaphragm muscles -- used in breathing
ParasymHeartRateIncrease	Transmission of message from cardio reg center to vagus nerve saying increase the h
IncreaseHeartRate	command to increase the beats per minute of the heart
DecreaseHeartRate	command to heart to decrease the beats per minute
ParasymIncreaseRate	Transmit message for an increase in heart rate thru the parasympathetic system, to ef
IncreaseRate	instruction for nerve to relay to increase the beats per minute of the heart
DecreaseRate	instruciton for nerve to relay to decrease the beats per minute
DilateArtery	Decrease artery diameter -- vasomotor response
ConstrictArtery	Artery diameter is decreasing--vasomotor response.
ReturnToNormalpO2	The pO_2 is high relative to its forerly too low value as measured by the aortic pO_2 sen
LowpO2	partial pressure of O_2 is low as measured by O_2 sensors in either the aortic body sen
IncreaseBP	Message that an increase in blood pressure is occurring.
DecreaseBP	Message that a decrease in blood pressure is occurring.
AveolarIrritantSensed	Presense of an irritant is communicated

Term	Definition
BronchioleIrritantSensed	presence of an irritant is communicated
LarynxIrritantSensed	presence of an irritant is communicated
TrachealIrritantSensed	presence of an irritant is communicated
TissDistressh	Lung tissue distress due to low oxygen or high CO2
TissDistressg	Esophegeal tissue distress due to low oxygen or high CO2
TissDistressf	Kidney tissue group distress due to low oxygen or high CO2
TissDistresse	Abdominal viscera tissue group distress due to low oxygen or high carbon dioxide
TissDistressd	Tissue group including visc and parietal served by the internal illiac artery distress due
TissDistressc	Low O2 or high CO2 distress in lower limb tissue
TissDistressb	Tissue distress call - not enough oxygen or too much carbon dioxide -- -in the head,ne
TissDistressa	The oxygen in the upper limb tissue group is too low, or the carbon dioxide is too high
TracActIS	The irritant sensor in the trachea is activated by the presence of particulates
LaryActIS	The irritant sensor in the larynx is activated by the presence of particulates
BronActIS	The bronchia irritant sensor is activated by the presence of particulates.
AvelActIS	The aveolar irritant sensor has been activited by particulates hitting it
AdminAlbut	Administer the medical drug albuterol
SmokeStreamStim	A smoke stream that is blown right onto the body; the stimuli exists right near the body
VaporCloudStim	A toxic vapor cloud is the stimuli; exists right near the body
MonoxideStim	The stimuli of carbon monoxide in gaseous form is immanent
ParticleCloudStim	In the particle cloud stimuli, ash particles are the stimuli
AdminMetha	Administer the medical drug methacholine.
Manager	**The Manager interaction group contains all Management Object Model interactio**
Federate	**The Manager::Federate interaction group contains all MOM interactions associa**
Alert	**The Manager::Federate::Alert interaction allows the RTI to inform the federation**
ServiceLog	**The Manager::Federate::ServiceLog interaction allows detailed tracing of RTIam**
ServiceLogArguments	**The Manager::Federate::ServiceLog::ServiceLogArguments interaction allows d**
ObjectInformation	**The Manager::Federate::ObjectInformation interaction is sent by the RTI in resp**
PublishingClass	**The Manager::Federate::PublishingClass interaction is sent by the RTI in respon**
SubscribingClass	**The Manager::Federate::SubscribeClass interaction is sent by the RTI in respon**
Action	**The Manager::Federate::Action interaction is used to preform an action on a re**
RequestPublicationTree	**The Manager::Federate::RequestPublicationTree is used to request that the RTI**
RequestSubscriptionTree	**The Manager::Federate::RequestSubscriptionTree interaction is used to reques**
SetTiming	**The Manager::Federate::SetTiming interaction allows modification of a federate'**
RequestObjectInformatio	**The Manager::Federate::Action::RequestObjectInformation interaction causes t**
ModifyAttributeState	**The Manager::Federate::Action::ModifyAttributeState interaction allows federat**
RemoteServiceInvocation	**The Manager::Federate::Action::RemoteServiceInvocation interaction group co**
DoResignFederationExec	**The Manager::Federate::Action::RemoteServiceInvocation::DoResignFederation**
DoDeleteObject	**The Manager::Federate::Action::RemoteServiceInvocation::DoDelete interactio**
DoSetLookahead	**The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead in**
DoSetTimeConstrained	**The Manager::Federate::Action::RemoteServiceInvocation::DoSetLookahead in**
DoTurnRegulationOn	**The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationO**
DoTurnRegulationOff	**The Manager::Federate::Action::RemoteServiceInvocation::DoTurnRegulationO**
Control	**The Manager::Federate::Action::Control interaction is used to set service loggin**

Class/Interaction	Term	Definition
NervousDuctwork	TransmissionFactor	Number between zero and one, inclusive, which degrades information b
Heart	HeartRate	beats per minute
	StrokeVolume	volume of blood pumped out of one ventricle of the heart in a single bea
	CardiacOutput	volume of blood pumper by the heart per minute
	PeripheralResistanc	total peripheral resistance from artery to capillaries
	ForceOfContraction	force with which the heart ventricle contracts in the pumping cycle
	BloodPressure	pressure of the blood in the blood vessels
Lungs	LungVolume	internal volume of the physical lungs (balloon like part)
	InternalLungPressur	air pressure inside the lungs; called intrapulmonary pressure also.
	OverallAirwayResist	resistance to airflow in the respiratory system
	TidalVolume	volume of air inhaled or exhaled during a regular breath
	DeadAirSpace	volume of respiratory system in which gas exchange does not take plac
	RespiratoryRate	breaths per minute
	LungCompliance	Volume change per unit change of pressure
	InspiratoryCapacity	The tidal volume plus the inspiratory reserve volume, about 3000 ml.
	VitalCapacity	The sum of the tidal volume, inspiratory reserve, and expiratory reserve
	TotalLungCapacity	The sum of the inspiratory reserve, expiratory reserve, tidal volume, an
	InspiratoryReserveV	The volume of air remaining after expiration of normal tidal volume; abo
	ExpiratoryReserveV	The volume of air remaining afer forced expiration of normal tidal volum
	ResidualVolume	Volume of air remaining after most forceful expiration, about 1200 ml.
IrritantSensor	Location	Anatomical location of the irritant sensot
	Status	The status is "ON" or "OFF"
TissueGroups	MetabolicRate	basal metabolism rate, consumption of O2 needed to maintain activities
	pCO2Waste	partial pressure of carbon dioxide in tissue groups
	pO2Demand	the partial pressure of oxygen needed for activity
	PeripheralResistanc	resistance to the flow of blood thru the tissue group; affects the blood pr
	O2ExtractionCoeffici	the coefficient of diffusion for oxygen across the membranes into the tis
	PercentCardiacOutp	The percentage of the total cardiac output that is being used by the tiss
	pO2ofTissueGrp	The actual partial pressure of oxygen of the tissue group
Epiglottis	status	OPEN or CLOSED are the two states that the epoglottis can be in
Human	HemoglobinBindingP	Percentage of hemoglobin sites that can be bound with O2 ; CO will st
	Age	how old the human body is
	Weight	the weight in a 1 g field
	Temperature	Temperature of the human
	HumanState	State of the human; only bsic states represented; alive or dead via an e
	ShuntFactor	Percentage of blood that is never oxygenated
ArteryinBody	pO2In	partial pressure of oxygen into artery
	FlowRate	rate of flow
	Diameter	diameter of artery
	pCO2In	partial pressure of carbon dioxide in the artery
Aorta	pO2In	partial pressure of oxygen into aorta
	pCO2In	partial pressure of carbon dioxide into the aorta
	FlowRate	flow rate of blood thru aorta
	Diameter	diameter of aorta
VeininBody	FlowRate	flowrate of blood in vein
	Diameter	diameter of vein
	pO2Out	partial pressure of oxygen in the vein -- carried out and away from the ti

Class/Interaction	Term	Definition
	pCO2Out	partial pressure of carbon dioxide in the vein -- blood being carried out a
Pharynx	Diameter	Effective Diameter of the pharynx, assuming a more or less circular cro
Larynx	Diameter	The effective diameter of the larynx (more or less circular cross section
Trachea	Diameter	The effective diameter of the windpipe with a circular cross sectional sh
Bronchia	Diameter	Effective diameter (organic conduit shape approximated by a circle) of t
SpinalColumn	CerebrospinalFluidP	pH of the spinal fluid
NasalCavity	NasalCavityVolume	Volume of the nasal cavity
	FlowRate	Rate of air flow in the nasal cavity
ThoracicCavity	ThoracicCavityVolu	Volume of the thoracic cavity; it changes with respiration, and must be
PleuralCavity	PleuralCavityVolume	physical volume of the pleural cavity
Abdominal	ContractionLevel	percentage of maximum contraction
ExternalIntercostals	ContractionLevel	Percentage of contraction
InternalIntercostals	ContractionLevel	percentage of maximum contraction
Diaphragm	ContractionLevel	Percentage of maximum contraction
LungConductingZon	AirwayResistance	resistance to the flow of air through the airway passages which decreas
LungRespiratoryZon	pO2staleBlood	partial pressure of O2 in the "used" blood which is flowing in capillaries
e	pCO2staleBlood	partial pressure of carbon dioxide in the used blood before it flows near
	pO2InspiredAir	partial pressure of oxygen in the air that is breathed in.
	pCO2InspiredAir	partial pressure of carbon dioxide in the air that is breathed in
	CO2DiffCoeff	diffusion coefficient of carbon dioxide through the capillary wall.
	O2DiffCoeff	Diffusion coefficient of O2 across the capillary wall.
	pO2Out	partial pressure of oxygen leaving he lung respiratory zone
	pCO2Out	partial pressure of carbon dioxide leaving the lung respiratory zone
	DMinverse	Diffusion resistance of the avelolcapillary membrane.
	MembraneSurfaceAr	Effective surface area of the respiratory membrance across which the g
	MembraneThickness	Thickness of the respiratory membrane
	AveolarVentilationRa	Good measure of air flow volume per minute; is the respiratory rate time
BAROAorticArch	Location	Physical location of sensor
	Status	"ON" or "OFF"
	BPChange	Change in blood pressure
	DirectionBPChange	"INCREASE" or "DECREASE"
BAROCarotidSinus	Location	Physical location of sensor
	Status	"ON" or "OFF"
	BPChange	Change in the blood pressure -- the delta.
	DirectionBPChange	"INCREASE" or "DECREASE"
MedulPHRecpt	Location	Physical location of sensor
	pHCerebroSpinalFlui	The pH of the cerebrospinal fluid.
	Status	"ON" or "OFF"
CarotO2Recpt	Location	Physical location of sensor
	pO2	The partial pressure of O2.
	Status	"ON" or "OFF"
AorticO2Recpt	Location	Physical location of sensor.
	pO2	The partial pressure of oxygen.
	Status	"ON" or "OFF"
HeartValves	Position	OPEN or CLOSED
HeartChambers	HeartChamberVolu	Volume of the heart chamber
	EfficiencyofContracti	How efficient the contractions are

Class/Interaction	Term	Definition
	pO2In	Partial pressure of oxygen in the blood in
	pO2Out	Partial pressure of oxygen in the blood leaving the chamber (should be
	pCO2In	Partial pressure of CO2 of blood coming into the chamber
	pCO2Out	Partial pressure of CO2 in blood leaving the chamber (should be the sa
MedullaVasomotorReg	status	the state of the regulatory center
	activityState	Qualitative level of activity in the state
	BPMonitorTissues	The vasomotor center serves to track the tissue blood pressures; gives
MedullaCardioReg	status	The state of the regulatory center
	activityState	Qualitative level of activity in the state
	BPHeartSysMonitor	Serves to keep track of the blood pressure in the core as opposed to th
MedullaRespirReg	status	The state of the regulatory center
	activityState	Qualitative level of activity in the state
InspiratoryCenter	CycleTime	The length of the time that the center can be actively sending out mess
ExpiratoryCenter	CycleTime	The lenght of time that the center can be actively sending out messages
MedulCO2Recpt	Location	Physical location of the sensor
	Status	"ON" or "OFF"
	pCO2	partial pressure of CO2 in the location of the sensor as mesured by the
BodyEnvironMatrix	ExternalTemp	The temperature of the surrounding environment
	AirPressure	The airPressure of the surrounding environment
	Altitude	The elevation above sea level of the location in which the body is locate
	LocationData	The physical location of the body
	Humidity	Value to indicate moisture content of the external air
	AirComponents	Percentages of oxygen, nitrogen, and carbon dixoide in the air surround
	BodyAffectors	Stimuli which affect the body
airMixture	perO2	Percent of oxygen in the environmental air
	perN2	Percent of nitrogen in the environmental air
	perCO2	Percent of carbon dioxide in the environmental air.
	altitude	The height above sea level.
	PotLevelofInjury	The potential gravity of the injury caused by the stimuli; may involve diff
	ImmediacyofEffect	How long before the stimuli takes effect
	TargetSystem	The body system which is affected by the stimuli
	IdentityProfile	The signature of the stimuli with regard to its effects on the body
	LocationXY	The latitude and longitude of this particular air Mixture
smokeGasMixture	perCO2	Percnetage of carbon dioxide in the gas mixture of smoke
	perO2	Percentage of oxygen making up the gases in the smoke stream
	perCO	Percentage of carbon monoxide making up the gases in the smoke stre
	perOtherInert	Percentage of other inert gases forming the gas mixture of the smoke st
	IndentityProfile	Stimuli signature wrt the body
	TargetSystem	Physiological system affected by stimuli
	PotLevelofInjury	The potential level of injury to the body -- generic -- can involve multiple
	ImmediacyofEffect	How fast acting is the stimuli
localParticleClusterCloud	SizeofParticles	Only one particle size is represented in this attribute
	ImmediacyofEffect	How fast acting is the stimuli.
	PotLevelofInjury	Potential degree of harm due to the receipt of the stimuli by the body;
	IndentityProfile	List of characteristics of the stimuli
	TargetSystem	The physiological system upon which the stimuli has an effect.
localChemicalVaporCloud	Concentration	Strength of the chemical vapor cloud

Class/Interaction	Term	Definition
Cloud	IdentityProfile	The characteristics of the stimuli
	ImmediacyofEffect	How quickly the stimuli has an effect.
	TargetSystem	The physiological system upon which the stimuli has an effect
	PotLevelofInjury	Potential degree of harm which the stimuli causes the recipient body; m
gas	ImmediacyofEffect	How quickly the stimuli has an effect.
	PotLevelofInjury	The potential degree of harm which the stimuli causes the recipient bod
	IdentityProfile	The characteristics of the stimuli
	TargetSystem	The physiological system upon which the stimuli has an effect
volatileChemicalVaporCloud	LocationXY	Physical location of the chemical vapor cloud given in xy coordinates
	CloudDiameter	Distance across the roughly spherical clooud
	Concentration	Level of chemical vapor cloud per cubic volume
	Altitude	Height above sea level of the center of the cloud
	LocationLL	The location of the toxic vapor cloud given in latitide and longitude
	ImmediacyofEffect	How quickly the stimuli has an effect.
	PotLevelofInjury	The potential degree of harm which the stimuli has upon the recipient b
	TargetSystem	The physiological system which is the target of the stimuli activity
	IdentityProfile	Characteristics of the sti,uli
	Speed	The magnitude of the velocity with which the stimuli is moving; used in g
	DirectionofMotion	The vector representation of the direction in which the stimuli is moving
O2	AmtO2	Amount of oxygen in the stimulus; measured as a percentage of a stand
CO2	AmtCO2	Amount of carbon dioxide in the stimulus; measured as a percentage of
CO	AmtCO	Amount of carbon monoxide in the stimulus; measured as a percentage
particleClusterCloud	LocationXY	Location of the center of the particle cloud in x , coordinates
	LocationLL	Location of the center of the particle cloud in latitiude and longitude
	ParticleSizeGroups	The particle size groups found in the particle cloud
	Altitude	The height above sea level of the roughly spherical particle cloud
	IdentityProfile	the characteristics of the stimuli
	TargetSystem	The physiological system which is the recipient of the sti,uli's effects
	PotLevelofInjury	Potential degree of harm that the stimuli has upon the recipient body; m
	ImmediacyofEffect	How quickly the stimuli has an effect
	Speed	The magnitude of the velocity vector of the stimuli; used in global repres
	DirectionofMotion	The vector representation of the direction in which the stimuli is moving,
Methacholine	Dosage	Amount
	PotLevelofInjury	Potential level of harm; may be mulitple levels depending upon amount,
	ImmediacyofEffect	How fast acting the stimuli is
	IdentityProfile	The identity of the stimuli vis-a-vis the recipient
	TargetSystem	The recipeint body system of the stimulus
Albuterol	Dosage	Amount
	ImmediacyofEffect	How fast acting the stimulus is; generic information
	TargetSystem	Recipient body system of the stimulus
	IdentityProfile	The identity of the stimulus vis-a-vis the recipient body
	PotLevelofInjury	Potential level of harm that could be generated by a stimulus; may be m
Federate	**FederateHost**	**The string representation of the hostname the federate is executin**
	FederateHandle	**The string representation of an integer that is the handle assigned**
	FederateState	**The string representation of the integer corresponding to the value**
	FederateName	**The string representation of the name speified by the federate at jo**
	RTIversion	**The string representation of the software version of the TRI library.**

Class/Interaction	Term	Definition
	TimeManagerState	The string representation of the integer correpsonding to the value
	FederateLookahea	The string representation of a double that is the value of the feder
	FederateTime	The string representation of a double that is the value of the federa
	TimeConstrained	The character representation of an integer that specifies whether t
	TimeRegulating	The character representation of an integer that specifies whether t
	FIFOlength	The string representation of an integer that specifies the number o
	TSOlength	The string representation of an integer that specifies the number o
	DequeueFIFOasyn	The string representation of the boolean value indicating whether
	TotalObjectCount	The string representation of an integer that specifies the total nu
	HoldingTokensObj	The string representation of an integer that specified the number
	DeletedObjectCoun	The string representation of an integer that specifies the number o
	NumAttributes	The string representation of an integer that acts as an indicator of
	NumParameters	The string representation of an integer that acts as an indicator of
Federation	FederationName	The string name of the federation.
	FederationState	The string representation of the integral value of the RTI::Federati
	FederatesInFederat	The string representation of the integral number of federates joine
	SaveIsScheduled	The string representation of the boolean value indicating whether
	ScheduledSaveTim	The string representation of the double-precision floating-point nu
	RTIversion	The string representation of the version number of the federation e
ChangeCycleTime	Direction	The direction "PLUS" or MINUS" of the change in the cycle time
	CycleChange	The change in seconds of the cycle time
ConstrictBronchioles	Amount	Value of change in effective diameter expresssed in percentage of nomi
TissDistressTrans	pO2TissGrp	The actual pO2 of the tissue group in distress
	Location	Origination of the distress signal -- ie, the tissue group
	pCO2TissGrp	Actual pCO2 of the tissue group in distress
	whichProb	String indicating whether problem is low O2,high CO2, or both
DecreaseHeartStrok	Amount	Magnitude of decrease measured in percentage of current value
IncreaseHeartStroke	Amount	magnitude of the force fo contraction expressed as a percentage of curr
HStrokeVolumeDecr	Amount	Magnitude of the decrease -- measured in percentage of current value
HStrokeVolumeIncrT	Amount	magnitude of force of contraction expressed as a percentage of current
ChemPHParasymTr	DecreaseInSV	Percentage decrease in stroke volume of heart
ans	DecreaseInHR	Percentage decrease in heart rate.
ChemPHSympTrans	IncreaseInHR	percentage increase in HR
	IncreaseInSV	percentage increase in Stroke Volume of heart
RelaxTransA	Amount	magnitude based as a percentage of the maximum
RelaxTransB	Amount	Magnitude of relaxation expressed as a percentage
ContractTransA	Amount	Magnitude expressed as a percentage of the maximum
ContractTransB	Amount	Magnitude of contraction expressed as percentage
ContractDiaphragm	Amount	magnitude expressed as a percentage of the maximum
ContractInternalInter	Amount	magnitude expressed as a percentage of the maximum
ContractExternalInte	Amount	Percentage change
ContractAbdominals	Amount	magnitude based as a percentage of the maximum
RelaxAbdominals	Amount	magnitude expressed as a percentage of the maximum
RelaxInternalInterco	Amount	magnitude expressed as a percentage of maximum
RelaxExternalInterco	Amount	Percentage of relaxation
RelaxDiaphragm	Amount	magnitude expressed as a percentage of the maximum
ParasymHeartRatel	Amount	percentage increase in present heart rate to effect a return to normal

Class/Interaction	Term	Definition
IncreaseHeartRate	Amount	number of beats/min to increase heart rate
DecreaseHeartRate	Amount	number of beats per minute to decrease
ParasymIncreaseRa	Amount	Percentage increase in heart rate to effect a return to noremal
IncreaseRate	Amount	number of beats per minute to increase the heart rate
DecreaseRate	Amount	number of beats per minute to decrease the heart rate
DilateArtery	Amount	Percentage decrease in artery diameter from current diameter
ConstrictArtery	Amount	percentage constriction relative to current diameter of the artery
ReturnToNormalpO2	pO2Value	partial pressure of O2 value in the location of the sensor
LowpO2	pO2Value	the value of the partial pressure of O2 as measured by the appropriate
IncreaseBP	Amount	Magnitude of increase in blood pressure.
	Location	Site of report of blood pressure increase
DecreaseBP	Amount	Magnitude of blood pressure decrease.
	Location	Location of the blood pressure sensor
AveolarIrritantSense	Location	Physical loation of the aveolar irritant sensor -- is in the LungRespirator
BronchioleIrritantSen	Location	Physical location of irritant sensor -- is in the RemainingBronciaNetwork
LarynxIrritantSensed	Location	Physical location of the irritant sensor
TrachealIrritantSens	Location	Physical location of the irritant sensor that's sensing the stimuli.
TissDistressh	pO2ofTissGrp	Acutal pO2 of lung tissue
	pCO2ofTissGrp	Actual pCO2 of tissue group
	whichProblem	String specifing if the tissue distress is due to low pO2 or hgh pCO2 or
TissDistressg	pO2ofTissGrp	Actual pO2 of esophegeal tissue
	whichProblem	String indicating which is the problem, high CO2, low O2, or both
	pCO2ofTissGrp	Actual pCO2 of the esophegeal tissue group
TissDistressf	pO2ofTissGrp	Actual pO2 of the kidney tissue
	pCO2ofTissGrp	Actual pCO2 of the kidney tissue
	whichProblem	String indicating if low oxygen, high carbond dioxde, or both are the pro
TissDistresse	pO2ofTissGrp	Actual pO2 of the abdominal viscera tissue group.
	pCO2ofTissGrp	Actual pCO2 of abdominal viscera tissue group
	whichProblem	String indicating if problem is low O2, high CO2, or both
TissDistressd	pO2ofTissGrp	Actual pO2 of the tissue group that is served by the internal illiac artery
	pCO2ofTissGrp	Actual pCO2 of the tissue group that is served by the internal illiac arter
	whichProblem	String indicating problem to be low O2, high CO2, or both
TissDistressc	pO2ofTissGrp	Actual pO2 of the lower limb tissue group
	pCO2ofTissGrp	Actual pCO2 of the lower limb tissue
	whichProblem	Sting indicating if problem is high CO2, low O2, or both
TissDistressb	pO2ofTissGrp	The actual partial pressure of oxygen in the head, neck, spine tissue gr
	pCO2ofTissGrp	Actual pCO2 of head,neck, and spine tissue
	whichProblem	String indicating if problem is low O2, high CO2, or both
TissDistressa	pO2ofTissGrp	Actual pO2 of the upper limb tissue group
	whichProblem	String indicating if problem is high CO2, low O2, or both
	pCO2ofTissGrp	Actual pCO2 of the upper limb tissue group
TracActIS	TurnOn	The trachea irritant sensor is activated; it can now do its activity
	LevelofIrritant	The level of the irritating particulates; high, medium, or low
LaryActIS	TurnOn	The irritant sensor in the larynx is activated by the presence of aprticula
	LevelofIrritant	The level of the particulate irritants; high, medium, or low
BronActIS	TurnOn	The bronchia irritant sensor is activated
	LevelofIrritant	Level of the particulate irritant; high, medium, or low

Class/Interaction	Term	Definition
AvelActIS	TurnOn	The sensor state is now activated.
	LevelofIrritant	The level of irritant hitting the sensor; high,medium , or low
AdminAlbut	Dosage	Amount
	ImmediacyofEffect	How fast acting a stimulus can be
	TargetSystem	The recipient system in the body
	PotLevelofInjury	Potential level of harm from stimulus; may be multiple levels depending
	IdentityProfile	Identity of the stimulus vis - a-vis the recipient body
SmokeStreamStim	Duration	Length of time the smoke stream is directly blowing at a body
	perCO2	percentage of CO2 in incoming smoke stream
	perO2	percentage of O2 in smoke mixture
	perCO	percentage of CO in smoke
	IdentityProfile	the identity profile of the smoke stream vis-a-vis the human body
	PotLevelofInjury	Potential level of injury
	perOtherInert	percentage of other inert gases in the smoke stream
	TargetSystem	Physiological system impacted by the smoke stream
	ImmediacyofEffect	How long it takes the stimuli to have an effect.
VaporCloudStim	Duration	Length of time the toxic vapor cloud is immanent
	Concentration	The concentration of the cloud in ml/cubic cm
	ImmediacyofEffect	How long it takes for the stimuli to have an effect.
	TargetSystem	The impacted physiological system
	PotLevelofInjury	The potential level of harm to the body
	IdentityProfile	Stimuli identification with respect to activity on the body
MonoxideStim	Amount	The amount of carbon monoxide that is input; measured as percentage
	Duration	Lenth of time that the stimulus is applied
	ImmediacyofEffect	How quickly the stimuli has an effect.
	IdentityProfile	The profile of the stimuli with respect to its effect on the body
	PotLevelofInjury	The potential level of injury to the body
	TargetSystem	The physiological system which is affected by the stimuli
ParticleCloudStim	SizeOfParticles	The average size of the particles in the particle cluster. Cluster particles
	Duration	Length of time the stimuli is operating
	ImmediacyofEffect	How quickly the stimuli has an effect
	PotLevelofInjury	The ptoential of harm to the body
	IdentityProfile	Who the stimuli is with respect to the body
	TargetSystem	The phsiological system affected by teh stimuli
AdminMetha	Dosage	Amount
	ImmediacyofEffect	How fast acting the stimuli is --nominal
	PotLevelofInjury	Potential level of harm; may be multiple levels; depending on amount, e
	IdentityProfile	The identity of the stimuli vis-a-vis the recipient body
	TargetSystem	The system of the body that is the recipeint of the stimulus
Federate	**FromFederate**	**The string representation of th inititating federate's handle.**
Alert	**AlertSeverity**	**The string representation ofthe integral vuale of the LogType enu**
	AlertText	**The string representation of the reason ofthe alert.**
	AlertID	**The string representation of the serial number for an exception.**
ServiceLog	**ServiceName**	**The string method name of the service call generating the interacti**
	ServiceInitiator	**The string representation the initiator of the service call (FED for R**
ServiceLogArgume nts	**Handle1**	**Meaning is dependent on service invoked. parameter tis represent**
	Handle2	**Meaning is dependent on service invoked. Parameter is represent**

Class/Interaction	Term	Definition
	HandleSet	Meaning is dependent on service invoked. Parameter is represent
	ObjectIDorCount	Meaning is dependent on service invoked. Parameter is represent
	TagOrLabelOrNam	Meaning is dependent on service invoked. Parameter is represent
	Time	The string representation of the time provided to the service invok
	Enumeration	Meaning is dependent on service invoked. Parameter is represent
	Boolean	Meaning is dependent on service invoked. Parameter is represent
ObjectInformation	ObjectID	The string representation of the ObjectID that this interaction id re
	LockedAttributes	The string representation of the attributes that are owned by a fed
	RegisteredClass	The string representation ofthe class that was registered by the re
	RepresentedClass	The string representation of the class that was discovered by the f
PublishingClass	ObjectClass	The string representation ofthe object class and attributes publish
	InteractionClass	The string representation of the interaction class handle. The for
SubscribingClass	ObjectClass	The string representation of the object class and dattributes publis
	InteractionClass	The string representation of the interaction class handle. The for
Action	ToFederate	The string representation of the federate's handle that the interacti
SetTiming	FedReportPeriod	The string representation of the integer that is the number of seco
	TimeReportPeriod	The string representation of the integer that is the number of seco
	ObjectReportPerio	The string representation ofthe integer that is the number of secon
RequestObjectInfor	ObjectID	The string representation of the ObjectID that information is being
ModifyAttributeStat e	ObjectID	The string representation of the object whose attribute token statu
	AttributeID	The string representation of the attribute whose instance's tolekn
	TokenState	The string representation of the integral value of the RTI::TokenSt
DoResignFederatio	ResignAction	The string representation of the integral value of the TI::ResignAct
DoDeleteObject	ObjectID	The string representation of the object ID to use as an argument to
	Time	The string representation of the federation to use as an argument t
	Tag	The string to use as an argument to the deleteObject service.
DoSetLookahead	Lookahead	The string representation of a double that is the value the federate'
DoSetTimeConstrai	State	The string representation of the an integer (Ture=0, False=1) that t
Control	SetServiceLogging	The string representation of the boolean value that enables/disable
	SetLogFile	The string representation of set log file.
	DeleteObject	The string representation of delete object.
	DequeueFIFO	The string representation of the DequeueFIFO.